TERRITORY OF PAPUA AND NEW GUINEA

DEPARTMENT OF AGRICULTURE, STOCK AND FISHERIES

ANNUAL REPORT

1959 - 1960

PORT MORESBY, JUNE, 1961

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His Honour the Administrator,

Brigadier D. M. Cleland, C.B.E., O.St.J.,

Territory of Papua and New Guinea.

Your Honour,

I have the honour to submit herewith the Annual Report of the Department of Agriculture, Stock and Fisheries for the year ending 30th June 1960.

As this is the first report of its kind presented by the Department, it was thought fitting to include brief background information on the Territory, a review of the production pattern for the last ten years, and an outline of the organization and functions of the Department, as well as a factual review of progress during the year.

Yours faithfully,

F. C. HENDERSON,

Director.

2790/61.

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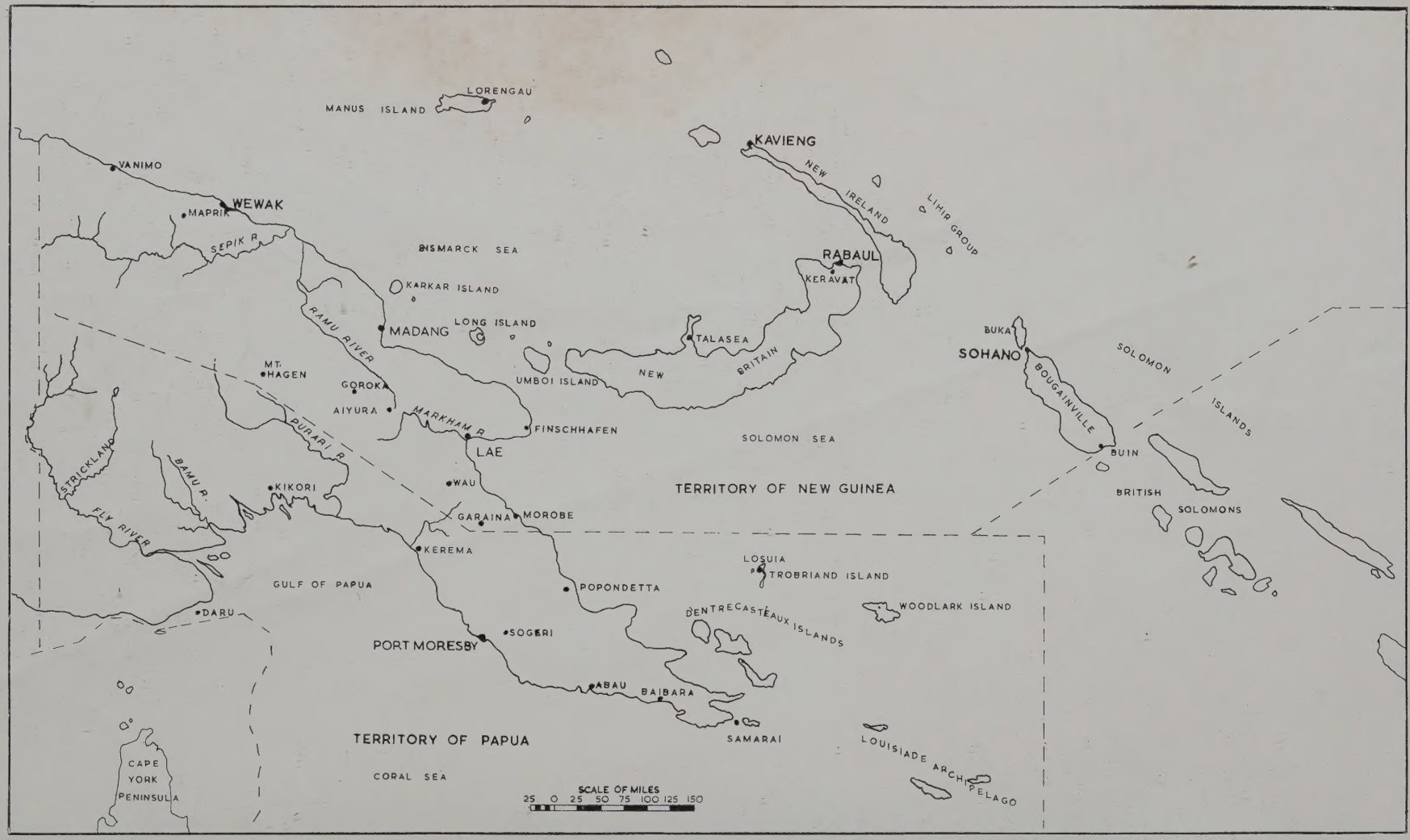

FIGURE 1—*The Territory of Papua and New Guinea—Political.*

THE TERRITORY OF PAPUA AND NEW GUINEA.

ADMINISTRATION.

The island of New Guinea and its associated islands are divided politically into three areas. The western part of the island is Netherlands New Guinea and the eastern part administered by Australia is further subdivided into the Territory of Papua, which is Australian territory, and the Territory of New Guinea, which is administered by Australia in trust from the United Nations Organization.

The Territory of Papua comprises the southern portion of the eastern half of the mainland, together with a large number of islands, the most important of which are the D'Entrecasteaux Group and the Louisiade Archipelago.

The Territory of New Guinea includes the northern half of the eastern part of the mainland and the major islands of New Britain, New Ireland, New Hanover, Manus, Buka and Bougainville, together with several hundred smaller islands. The geographical boundaries of the Territory of Papua and New Guinea are shown in Figure 1. Together the Territories form an administrative union, the headquarters of the Administration being at Port Moresby in Papua; all Departments serve both Territories.

PHYSIOGRAPHY.

The total area of the Territory of Papua and New Guinea is 183,500 square miles. New Guinea and its associated islands represent the eastern extremity of the great arc of fold mountains which extend through the Himalayas and Malaya into the Pacific. Within the island of New Guinea, the central core of this zone of uplift and folding is a massive cordillera which extends from one end of the island to the other—a distance of about 1,500 miles. This cordillera is one of the great mountain systems of the world. In several places it reaches heights in excess of 15,000 feet and includes some of the world's most rugged country. The highest peak in the areas administered by Australia is Mount Wilhelm (15,400 feet) in the Bismarck Range, although there are several peaks in Netherlands New Guinea over 16,000 feet high and permanently snow-capped.

The mainland of New Guinea has several very large rivers of which the Fly, Sepik, Purari and Ramu are outstanding.

Volcanic activity has played an important part in the evolution of New Guinea and other islands in the Territory. Most of the mainland volcanoes are now quiescent. There is a very active volcanic island just off the north-eastern coast.

The major physiographic regions of the mainland are the Main Ranges, the Northern Mountains, the Central Depression, the Southern Foothills and the Southern and Northern Coastal Plains and Swamps. Their approximate boundaries are shown in Figure 2. Each of these zones will be discussed and the more important of the associated islands will also be considered.

The Main Ranges extend throughout the length of the island and form a complete divide between north and south-flowing drainage. They do not constitute a single chain but consist of a complex system of ranges frequently separated by broad upland valleys.

The principal units in Eastern New Guinea are the Star Mountains (extending across from Netherlands New Guinea), the Hindenburg, Muller, Kubor, Schrader, Bismarck and Owen Stanley Ranges. Each of these reaches an altitude of 10,000 feet or more and each has an individual character which is generally in accordance with its geological structure.

The width of the Main Ranges varies from 50 miles to 150 miles. Broad grass covered valleys are found in the wider parts of the highlands. These valleys contain areas of high fertility and generally enjoy a good climate. Marginal to the highlands, dissection has been proceeding apace and has resulted in extensive rugged juvenile topography.

The Northern Mountains comprise a series of ranges running parallel to the main ranges but separated from the latter by the Central Depression. These Northern Mountains are not as wide nor as high as the main range system but nevertheless contain some very rugged country, particularly in the Finisterre Range. The ranges which constitute the Northern Mountains running east from Netherlands New Guinea are as follows:—Bewani, Torricelli, Prince Alexander Mountains (north of the Sepik River) and the Adelbert, Finisterre and Saruwaged Mountains (between the mouth of the Ramu River and the Huon Gulf).

The Central Depression separates the Northern Mountains from the main ranges. It is a great trough-like depression of structural origin. It includes the valleys of the Sepik and Ramu Rivers which drain in opposite directions to enter the sea close to each other between Hansa Bay and Wewak, and the Markham Valley which drains into the Huon Gulf near Lae.

Because of its low gradients and the impeded drainage conditions of the valley floor, much of the Sepik Valley is subject to flooding. Swamps are intensively developed on the land adjoining the lower half of the river. The Ramu Valley in many ways resembles the Sepik although a much smaller proportion of the valley lies below the 100 feet contour. The Markham Valley is also superficially similar in that there are extensive grass covered swamps with scattered forest clumps and the valley slopes are covered with grass.

The Southern Foothills.—Between the central cordillera and the coastal area of Western Papua is an extensive zone of foothills which rise tier upon tier from the Lowland Plains. The western margin of the foothill zone is the headwater tract of the Fly River. The eastern margin is more difficult to define as the zone gradually narrows down, finally terminating in the Lakekamu Embayment area near Kerema on the Gulf of Papua.

East of the Delta Embayment (at the head of the Gulf of Papua) the physiography is greatly influenced by the geological structure. In this area there has been much folding, which has produced many mountain scarps.

In the past this foothill zone has been greatly influenced by volcanic activity and today the dome-like stumps of ancient volcanic mountain clusters surrounded by plains of volcanic detritus are still to be seen. The Bosavi Mountains, rising to a height of 8,000 feet, Mount Fevenc (6,000 feet), Mount Murray (8,000 feet) and Mount Sisa (9,500 feet), are all extinct volcanoes.

Limestones also play a prominent part in the physiography of the Southern Foothills, particularly in the Strickland-Purari area, where nearly all the prominent ridges and some extensive plateaux are of limestone. Sheer limestone walls occur frequently and make overland transport extremely difficult. On the surface of the plateaux, the limestone is often broken by sink holes up to 300 feet in depth and there is a complex underground drainage system. From the air, these plateaux appear to consist of masses of needlepoint pinnacles although the general level is that of a normal plateau.

Just north of the limestone region is a zone of grassy upland valleys generally leading northward into the Central Mountains. Prominent amongst these are the Tari, Mendi, Kagoli and Wahgi River Valleys.

East of the limestone region is a very mountainous area comprising several ranges known as the Kukukuku Mountains. The highlands behind Kerema are particularly precipitous and include some of the most rugged country in Papua. The coastal hills of the Kukukuku Mountains have large areas of flat, often swampy country through which run ridges usually under 500 feet in height. The lower foothills are more rugged and contain mountains and ridges rising to nearly 4,000 feet with precipitous valleys clothed in dense jungle. Most of the broken country is in the transient zone between the lower and upper foothills where the streams are entrenched in canyon-like valleys and contain numerous waterfalls.

The Southern Coastal Plains and Swamps.—The southern littoral is a continuously sinking zone. Subsidence is general, although more rapid, in the geological sense, in the eastern (Port Moresby) sector, which faces greater oceanic depths than in the western (Daru) sector, which faces the more stable region known as the Australian shield.

The Daru coast includes the great Delta plains of the Turama, Aworra-Bamu and Fly and Strickland Rivers backed by high non-resistant mountains subject to heavy tropical rain. The rivers carry heavy loads of alluvium with which they are building out their deltas over the slowly-subsiding continental shelf to the south. The whole area is very flat and may not rise appreciably above sea level for as much as 20 miles inland. The section of the vast deltaic area from the Fly River to the Kukukuku Mountains where the foothills come down to the sea is known as the Delta Embayment.

Just inland from the shoreline of the Daru coast area is the Oriomo Plateau which is a very distinctive topographic feature. It is 300 miles in length, stretching from the Fly River over into Netherlands New Guinea, and has an average width of 50 to 80 miles. It rises to some 200 feet above the surrounding marshlands and the surface is mainly alluvium with underlying limestone broken occasionally by sink holes.

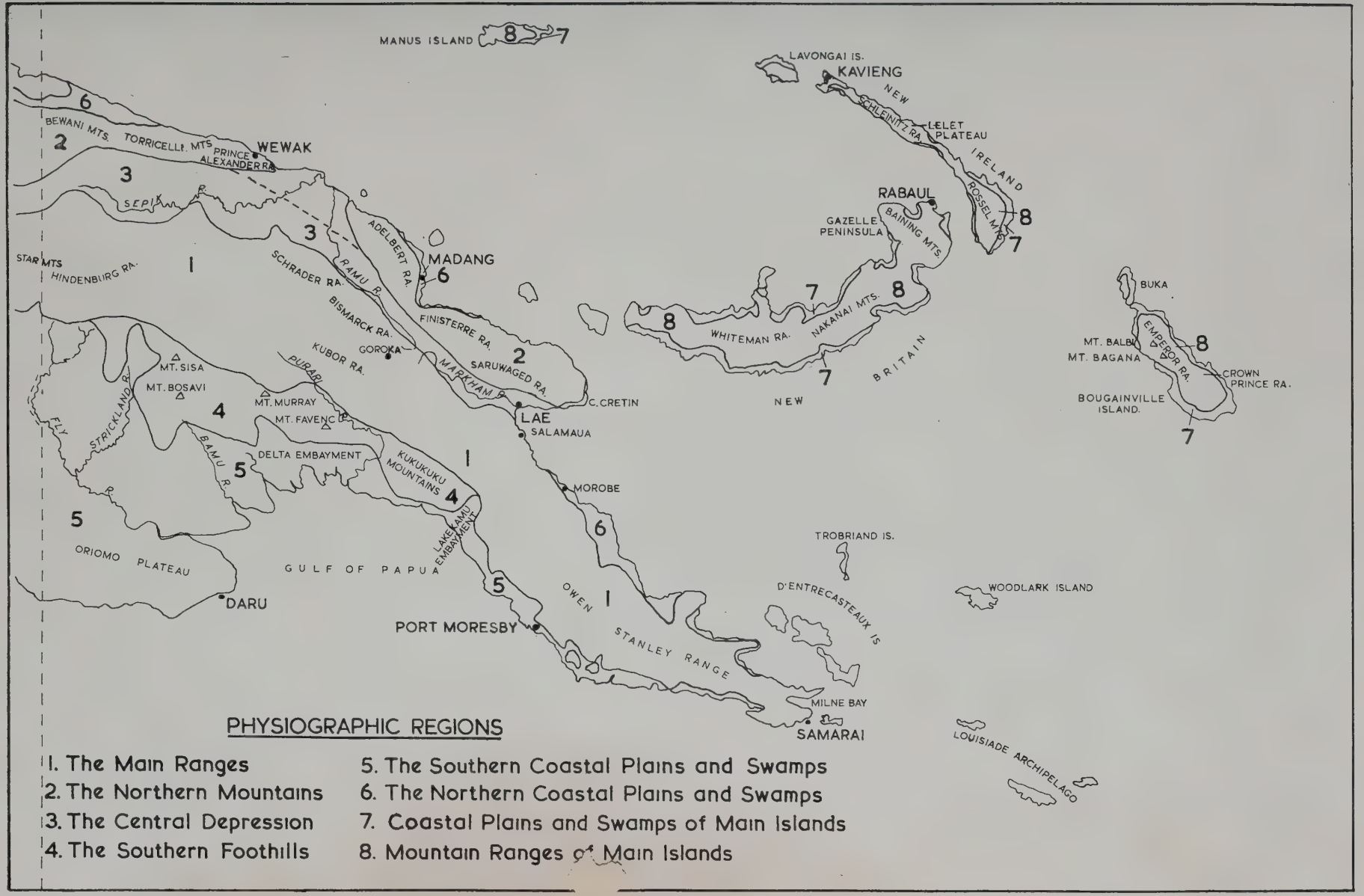

FIGURE 2—*The Territory of Papua and New Guinea—Physiographic Regions.*

The Moresby coast stretches from Deception Bay at the head of the Gulf of Papua south-eastwards through Port Moresby almost to the China Straits. Much of the coast fronts the deep Coral Sea and the shoreline consists of rocky headlands and the seaward ends of the ridges, alternating with wide sweeping beaches which are in distinct contrast to the marshlands of the Daru coast. However, swampy coastal plains frequently occur between the foothills and the coast and drowned estuaries are common. Intermittent fringing barrier reefs occur but raised coral reefs extending inland from the beach are never found.

The Northern Coastal Plain and Swamps.—With the exception of the Papuan Peninsula south of the Markham River, most of which is sinking, the whole northern littoral is rising. This is in direct contrast to the sinking south littoral and has resulted in the production of a markedly different coastal pattern. One of the most significant features is that, with very few exceptions, the rivers are not navigable. Another feature is the presence of raised reefs which extend almost continuously from the Sepik Delta south-easterly to Cape Cretin. The Morobe coast between Salamaua and Morobe is a drowned littoral and there is a total absence of raised coral from the mouth of the Markham River to the Papuan border. However, the most southerly tip of the Papuan Peninsula is rising and raised coral reappears around the shores of Milne Bay. A notable feature of the north coast is the belt of offshore volcanic islands which stretches from Wewak to Dampier Strait, west of New Britain.

The Islands of Papua-New Guinea.—Agriculturally speaking, several of the islands of Papua-New Guinea are of great interest as they have intensive agricultural development.

New Britain is the largest of the islands of the Bismarck Archipelago. There are two main lines of ranges in the island—the Whiteman and Nakanai Ranges in the south which run from south-west to north-east and the Baining Mountains of the Gazelle Peninsula running north-west to south-east. The low relief of the north coast is broken by a large number of sharp volcanic peaks, some of which reach 7,000 feet in height. These volcanoes are mostly of the explosive type and catastrophic eruptions have occurred in recent times. At the western end of New Britain is a cluster of volcanic mountains containing several peaks over 3,000 feet in height. Another group of volcanoes occurs further east in the Kimbe Bay and Open Bay areas and there is an area of very recent volcanism on the Gazelle Peninsula in the vicinity of Rabaul. Almost all of New Britain is of a mountainous nature, although there are some coastal plains and swamps, and the area around Rabaul is of great agricultural importance. The coastline is approximately 1,000 miles in length and fringing and barrier coral reefs, although not continuous, are extensively developed.

New Ireland, which is nearly 200 miles long, averages only 7 miles in width, except in the south-east where it extends to 30 miles. It is exceedingly mountainous with the Schleinitz Mountains in the northern part rising to 4,100 feet and the Rossel Mountains in the south to 6,430 feet. To the south-east of the former is the extensive Lelet Plateau with a mean height of 2,600 feet.

The coasts of New Ireland are relatively straight and afford little shelter. They have been subject to recent elevation and there has been extensive development of raised coral reefs, especially on the east coast.

Manus Island is about 50 miles long from west to east and its greatest width is about 17 miles. The island is largely hilly and deeply dissected. Along the coast, steep slopes alternate with swampy lowland embayments, there being no continuous coastal plain. Practically the whole of Manus is fringed by coral reefs.

The Solomon Islands.—Bougainville is the largest island in the Solomons, being about 127 miles in length with a maximum width of 49 miles. The interior of the island contains a massive mountain range which follows its length and is known as the Emperor Range in the north and the Crown Prince Range in the south. It contains two active volcanoes, Balbi (8,502 feet) and Bagana (5,730 feet). Shoals and fringing coral reefs are common off the coast. The interior of the island is still very imperfectly known.

Buka Island, just north of Bougainville, is 35 miles long and 9 miles wide. A low range of volcanic hills reaching a maximum height of about 1,300 feet follows the west coast. This range is fronted on the east coast by a lower parallel range of hills formed of coral limestone, terraced on their seaward slopes. The west and south coasts are protected by fringing barrier reefs.

The D'Entrecasteaux Islands and Louisiade Archipelago.—The main cordillera of the island of New Guinea does not end abruptly at the tip of the Papuan Peninsula but continues to the south-east as a series of small islands. These fall into two fairly distinct groups, the

D'Entrecasteaux Islands and the Louisiade Archipelago. Coral reefs are typical and are very extensively developed in the Louisiade Archipelago. The D'Entrecasteaux group consists of three large islands, Goodenough, Ferguson, and Normanby and very many small islands. Since they represent the peaks of a submerged mountain range, the islands are steep and rugged. They are mainly of volcanic origin but there are recently elevated masses of coral limestone in coastal areas.

The three main islands of the Louisiade Archipelago are Misima, Tagula, and Rossel. These islands have a complex history and are composed mainly of metamorphic rocks, together with coral limestone, the latter being especially common on the smaller islands.

The Trobriand Islands and Woodlark Island.—These islands are physiographically separate from the main cordillera. The most important island in the Trobriand group is Kiriwina which is 30 miles in length and 3 to 10 miles wide. It is fairly flat and appears to be a raised coral atoll. Woodlark is an irregular island about 44 miles from east to west and 5 to 18 miles in width. It has much raised coral in its surface although generally low lying. There are three raised areas, one of which, near the south coast, reaches a height of 1,200 feet.

New Britain and New Ireland, Manus and the Solomon Islands, together with their associated smaller islands, are politically grouped in the Territory of New Guinea whereas the D'Entrecasteaux group, the Louisiade Archipelago, the Trobriand Islands and Woodlark Island are in Papua. In addition to these large islands, there are many hundreds of minor islands, considerable numbers of which are inhabited and some are of agricultural importance. The majority of the small islands are atolls or coral islands but important volcanic islands also occur.

DRAINAGE.

The heavy rainfall of the mainland of New Guinea and the principal associated islands, coupled with the large area of steep slopes with consequent rapid run-off, has been responsible for the development of many rivers with a large volume of flow. With some notable exceptions, the rivers are not navigable except by canoes or small launches in the lower reaches. Mountain streams are found extensively throughout the Territory; indeed they are frequently a major hindrance to travel as they carry huge volumes of water after heavy rain.

Swamp rivers with brownish-coloured water carrying large quantities of organic matter occur on the wide southern lowlands. Extensive swamps are also found in the Territory, falling into the three groups of tidal swamps, riverine swamps and grassy marshes. Very extensive grassy marshes are developed in the mid-Fly, mid-Sepik and mid-Ramu areas where the low-lying terrain is almost continuously under water.

The largest rivers are the Fly, the Sepik, the Ramu, the Purari and the Markham.

The Fly is not only the largest river in Papua-New Guinea but its flow is so great that it ranks with the world's greatest rivers in spite of its relatively short length. It is over 700 miles long, 33 miles wide at the entrance to the estuary (or 10 miles at the mouth proper beyond Kiwai Island), and is navigable by vessels drawing less than 8 feet for nearly 500 miles during the whole of the year. The Fly River, fed by many tributaries draining the mountainous interior with its great rainfall, transports vast loads of alluvium. The deltas of the Fly and Purari form an almost continuous series and this has led to the development of one of the largest estuarine areas in the world.

The Sepik, which drains the western half of the Central Depression, is next to the Fly in size. It is about 700 miles in length but unlike the Fly is only 1 mile wide at its mouth. It rises in the Star Mountains deep in the rugged interior of New Guinea and its headwaters are separated from those of the Fly by only about a mile. It may be navigated for 300 miles by vessels drawing 13 feet; over this distance the river rises only 26 feet. Towards the mouth there are numerous extensive meanders and ox-bow lakes created by past changes in course.

The Purari river, although the third largest in the Territory of Papua-New Guinea, is still comparatively unexplored. It rises in the Central Plateau and flows for over 300 miles through the rugged interior to enter the sea in the Gulf of Papua. The main river source is separated from the source of the Ramu by a narrow divide near Kainantu; the source of its major tributary, the Wahgi River, is at Mount Hagen. The Wahgi and the Purari, above their junction, both flow through densely populated grassy highland valleys which are much less precipitous than those of the middle Purari, where the river breaks through successive parallel ridges in a series of deep and steep-walled gorges.

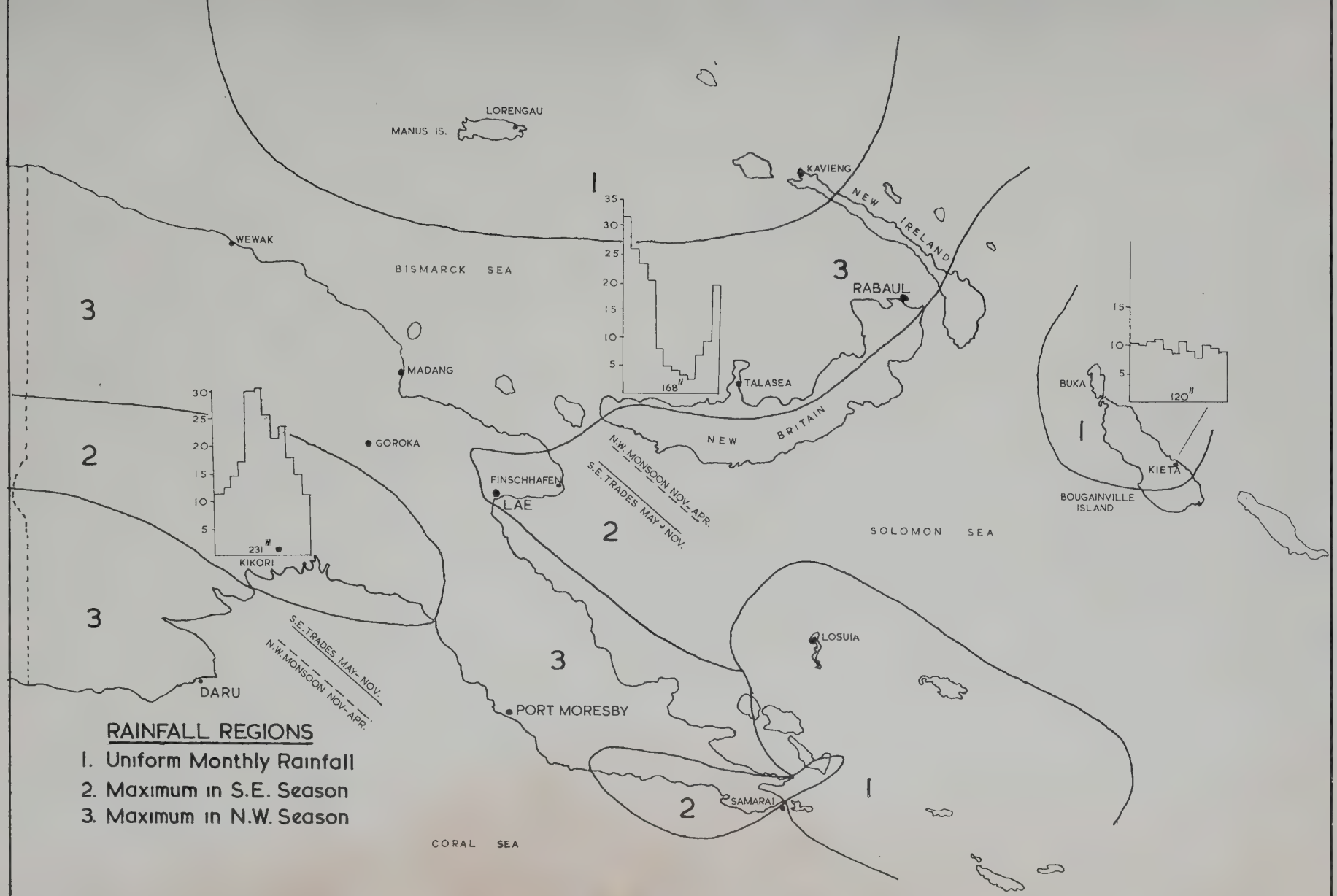

FIGURE 4.—Rainfall Regions of the Territory of Papua and New Guinea.

The Ramu, approximately 450 miles in length, debouches near the mouth of the Sepik. However, unlike the latter river it is difficult of entry and easily navigable by launches for only a short distance upstream. The river rises in the Kratke Ranges near the source of the Purari River and breaks through the Bismarck Range in a great gorge to enter the Central Depression. After leaving the gorge, it falls only slowly for several hundred miles and in the last 160 miles, where meanders and swamps are common, the fall is imperceptible.

A river of quite different type is the ***Markham*** which rises in the Finisterre Ranges, drains the eastern end of the Central Depression and enters the sea near Lae on the Huon Gulf. It is only about 110 miles long but is very wide and discharges a great volume of water. Because of its numerous braided channels, shifting sandbanks, fast flow and occasional shallowness, the Markham River is not navigable. Except for the first 15 miles of its course through rugged valleys of the Finisterre Ranges, the descent of the river is gradual through the grass covered Markham Valley.

CLIMATE.

The Territory of Papua–New Guinea lies wholly within the inner tropics and experiences a tropical monsoonal climate with the north-west monsoon blowing from about December to March and the south-east monsoon from May to October, with periods of variable winds and doldrum weather during the changeover at each season.

The north-west monsoon and the south-east monsoon pass over large expanses of ocean before reaching the islands of the Territory and both are thus heavily laden with moisture. The precipitation of this moisture results in heavy rainfalls throughout the area and most places in the Territory have an average annual rainfall in excess of 80 inches; large areas have rainfalls greatly in excess of this figure. The highest figures are recorded on coasts and mountain sides exposed to the steady south-east trades. The south of New Britain and the high mountains of the Huon Peninsula receive an average of at least 250 inches per annum. Kikori on the Gulf of Papua receives over 200 inches per annum and the rainfall is probably higher over the extensive inland area adjoining this recording station. Wide valleys parallel to the coast such as the middle Ramu Valley and middle and upper Markham Valleys and enclosed valleys in the Highland regions such as the Bulolo Valley, lie in " rain shadow " zones and have rainfalls down to about 60 inches per annum. Port Moresby, because of the land configuration in that area, lies in the centre of a large rain shadow along the central coast of Papua and has the lowest rainfall in the Territory at about 40 inches per annum. The main rainfall zones are shown in Figure 3.

Some parts of the Territory have a more or less uniform rainfall distribution, e.g., Losuia in the Trobriand Islands and Buka in the Solomons, but most places experience a definite seasonal distribution of precipitation, this being the resultant effect of topography and prevailing winds. The island of New Britain illustrates this effect perfectly. As the median mountainous backbone of the island lies athwart the direction of the seasonal winds, the north coast of the island receives the bulk of its rainfall in the north-west monsoonal season while the situation is reversed on the south coast of the island, which is more or less in a rain shadow during the north-west monsoon. In the south-east trades season, the concentration of rainfall occurs on the southern coast while the protected north coast remains relatively dry. Rainfall distribution in the Territory is shown in Figure 4.

As the whole of the Territory lies within 12° of the Equator, there is little difference in day length throughout the year.

Atmospheric temperature and humidity are high throughout the year at all coastal stations and there is little variation in this regard between centres, irrespective of rainfall. Mean maxima are about 90° F. and the minimum rarely falls below 70° F. on the coast. Extremes of temperature are unknown and as the inland is elevated, the Territory experiences an insular rather than a continental climate. Temperatures, of course, fall steadily with altitude and above 7,000 feet occasional frosts are experienced, increasing in severity and frequency as altitude rises further.

SOILS AND AGRICULTURE.

Although subsistence agriculture is practised to a greater or lesser extent on almost every soil type within the range of habitation, the main commercial agriculture of the Territory is closely associated with the soil patterns of certain districts and it is appropriate to consider soils and agriculture in conjunction. As would be expected in view of the geology

and physiography, there is a marked diversity of soils in the Territory. They are discussed in this section in relation to the physiographic units already outlined. The bulk of the soils are developed on parent material of Upper Tertiary, Pleistocene and recent origin, together with metamorphic and intrusive igneous rocks. Some material of Mesozoic age occurs in the Central Highlands region.

The Main Ranges.—With the exception of the Owen Stanley Range, these ranges are composed mainly of Upper Tertiary sediments and limestones together with some of Mesozoic age. In addition, significant areas of Pleistocene volcanic deposits and igneous intrusions occur. The volcanics are predominantly andesitic in character and deposited as ashbeds, whilst the igneous intrusions are granites and diorites. The Owen Stanley Range consists chiefly of metamorphics which occur also along the northern flank of the Main Ranges. Numerous igneous intrusions are found throughout the Owen Stanley Range as well as a number of Pleistocene lacustrine deposits.

Under these mountainous conditions, considerable variation in soils occurs. Dark brown loams and clays are developed on the high mountains, their depths depending on the stability of surfaces. Differences in the composition of parent rock are not reflected to any extent in the profiles developed. The volcanic deposits have given rise to red to orange silty loams and silty clays. The broad highland valleys found between individual ranges are chiefly lacustrine deposits, and in the poorly drained areas, short grass swamps are found, giving rise to peats 3 feet to 8 feet in depth overlying pale grey sands, silts and clays. On the areas with better surface drainage and flat to rolling topography, well-defined ironstone concretionary layers occur in the B horizon. The soils are usually peaty loams overlying stiff clay sub-soils.

The ultrabasic material on the northern flanks of the Owen Stanley Range has given rise to very deeply weathered soils almost completely leached of bases and silica.

Arabica coffee growing, which is the main commercial form of agriculture in this topographic unit, has taken place largely on the soils derived from volcanic deposits and, following drainage, the peaty valley soils. Coffee is also established on the soils derived from diorites.

There is also some commercial exploitation of lacustrine deposits in the Owen Stanley Range. These occur at varying altitudes and exhibit marked variation in composition. At Kokoda, soils similar to those of the adjacent volcanics occur and are used for rubber planting. At Wau, the lacustrine soils are heavy acid clays, often laterized, and used for coffee growing and grazing.

The Northern Mountains. The Northern Mountains are comprised mainly of Upper Tertiary sediments. Those mountains north of the Sepik River are marine and lacustrine sediments extensively intruded by diorites and to a limited extent by granites. Calcareous and non-calcareous sediments occur and range from claystone to sandstone and conglomerates.

There is considerable local variation in the soils. On the non-calcareous sediments they are chiefly brown loams overlying pale subsoils usually mottled with orange yellow, the texture being influenced by the nature of the parent material. They are moderately acid in the topsoils and neutral in the subsoils. The soils developed from calcareous sediments are generally better structured and deeper coloured, developing orange and orange-brown colours in the lower part of the profile. They are neutral at the surface, increasing in alkalinity with depth.

The Northern Mountains approach the coast closely, leaving only a narrow strip of coastal plain which is composed of recent alluvial and colluvial material of varying texture and drainage. These alluvials are phosphorus deficient and often base-saturated.

The mountains east of the mouth of the Ramu River consist of Upper Tertiary sediments and limestones, together with volcanics of similar age, largely olivine basalts. At higher altitudes the soils are friable brown clays, often shallow, whilst lower down they are red-brown or red clays, usually shallow and eroded, and lithosols are also found. To the north of Madang, there is a narrow coastal plain in the form of a recent raised coral shelf giving rise to well-drained yellow and red-yellow acid clay loams. There are areas of volcanic sands opposite an active off-shore volcano. To the south of Madang is an area of grey heavy-textured recent alluvium, often water-logged.

The costal plain north of Madang is extensively developed with plantation agriculture, coconuts being predominant, with cacao on the volcanic sands.

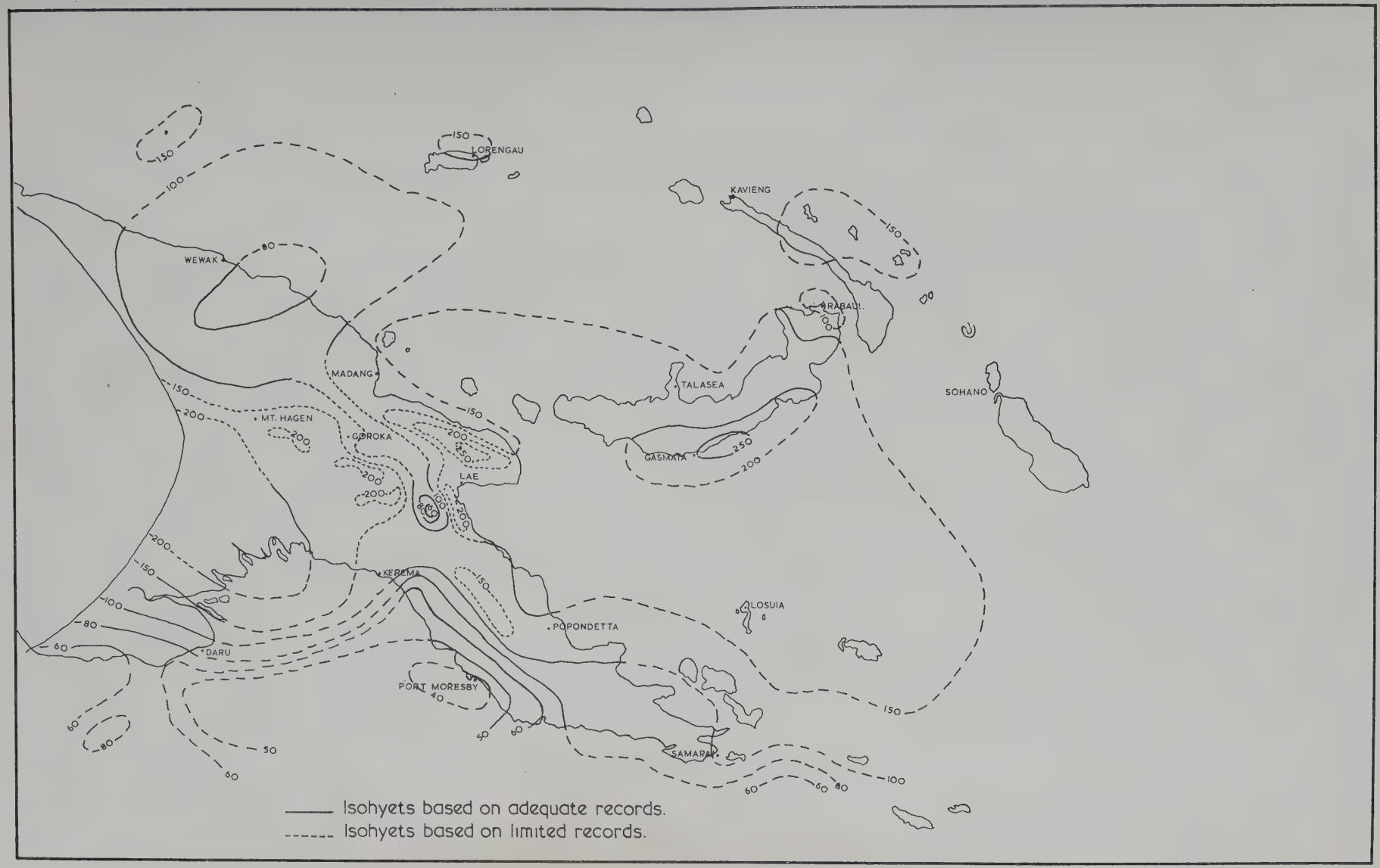

FIGURE 3—*Rainfall Map of the Territory of Papua and New Guinea.*

The Central Depression is an area of recent alluvial deposition, with a peripheral zone of Pleistocene deposits and a limited area of Upper Tertiary sediments, probably occurring as outliers of the Northern Mountains. The Markham-Ramu trough is included in the Central Depression.

The soils of the main Ramu-Sepik area are recent alluvials generally subject to periodic, and often prolonged, inundation. The soils are usually medium to fine-textured alluviums with occasional black clays. Lowland peats occur in swamps adjacent to the coast at the confluence of the Sepik and Ramu. The utilization of the soils on the Ramu-Sepik area is generally dependent on the degree of flooding experienced.

The Ramu-Markham trough presents a superficially similar set of conditions but there are in fact considerable divergencies. Extensive swamp areas do not occur although swampy conditions are associated with the distal extremities of the rubble fans built up by the northern tributaries of the Markham River. In both the Ramu and Markham Valleys, the rivers run on the south side and develop their primary flood plain to the north. The major northern tributaries have built up coarse unconsolidated colluvial fans overlain by a shallow silt loam up to 12 inches in depth; between the fans, deep silt loams overly sands. These alluviums, which are derived mainly from the olivine basalts and limestones of the Northern Mountains, are alkaline in character and this factor, together with the markedly monsoonal rainfall distribution, has led to the development of a montmorillinitic type of soil as is associated with margallitic-type weathering. All the soils in this area are essentially alkaline, while those of the Sepik-Ramu confluence tend to be base saturated or approaching this condition.

The deep soils of the Markham-Ramu are extensively utilized for peanut growing and the shallow fan soils are being developed for grazing.

The extensive Sepik Plain area forming part of this region is a Pleistocene deposit and again quite different in character. The soils developed are quartzitic sandy loams overlying pale grey mottled clays, often with massive ironstone concretions in the B horizon. These soils are acid and particularly leached and infertile. They support practically no subsistence agriculture and there is no commercial development.

The Southern Foothills. This area consists of Upper Tertiary sediments and limestone with three known areas of Pleistocene volcanic deposits. The topographic character of the area, coupled with its inaccessibility and low population density, have meant that no intensive studies have been carried out in the area and the general soil characteristics are virtually unknown.

The Southern Coastal Plains and Swamps may be conveniently divided into two areas by the Southern Foothills which approach the coast in the vicinity of Kerema. To the west there is a zone of rapidly-changing rainfall, ranging from 200 inches, well distributed, to 60 inches with a distinct monsoonal distribution, at the Netherlands New Guinea border.

Three distinct land surfaces are discernible, the first being the recent alluvium associated with all the main river courses and deltas, particularly the Fly River. Such areas are very low-lying to the extent that 500 miles up the Fly River the altitude is under 200 feet above sea level: consequently they are inundated annually for prolonged periods.

Pleistocene alluvials occur in the regions furthest west. They are slightly elevated but poorly drained and give rise to heavily laterized or alternatively shallow loams, overlying stiff impervious clays. These soils match the Sepik Plain in infertility while the poor rainfall distribution further accentuates the limitations on their value.

There is a limited area, opposite Daru, of Upper Tertiary limestone deposits which form the eastern end of the Oriomo plateau. The soils in this area have characteristics generally similar to those formed from the Pleistocene deposits.

East of Kerema there is a relatively narrow coastal belt of recent alluvium backed by a discontinuous belt of Upper Tertiary volcanics, together with a limited belt of Lower Tertiary sediments in the Port Moresby–Rigo area. The alluviums are generally silts and sands although there is gradation in textural character from dark grey heavy clay loams to clay in the southern section and to light grey silts and sands in the north. To the south the presence of Upper Tertiary sediments gives rise to laterized clays, while from the Lower Tertiary deposits in the rain shadow area are formed relatively infertile black clays with a typical montmorillinitic character.

By virtue of the ultrabasic character of the Owen Stanley Ranges behind this area, most recent alluvials tend to be base-saturated or at least have a high Ca^{++} and Mg^{++} content. This is reflected in the pH levels, which are only slightly acid or neutral in the surface horizons. There has been a limited development of coconut and rubber plantations on these soils.

The Upper Tertiary volcanics are mainly basaltic and gabbroitic in character, occur under relatively high rainfall conditions and have developed deeply weathered orange to red profiles. They are very acid, free draining and highly leached and are typical examples of Hallsworth's krasnozems. These soils have been developed extensively with rubber planting in the vicinity of Port Moresby.

The Northern Coastal Plains and Swamps. There is a very limited development only of this area in the Territory of New Guinea but it is of some importance on the north-east coast of Papua. These areas are principally recent alluvium derived from the Owen Stanley metamorphics, together with three zones of Pleistocene volcanic activity and two zones of recent volcanic activity.

To the south is a region of Lower and Upper Tertiary sediments occupying a rain shadow area and giving rise to shallow black clay soils on steep topography. The recent alluvials are generally fine textured, low lying and poorly drained but the texture is coarser adjacent to the principal streams.

The volcanic deposits are of the Mount Pele type. Medium-deep weathered clay loams occur in the immediate vicinity of the volcanoes, while coarse mineral sand ash flows radiate at a distance and are often characterised by a kunai grass vegetation.

These soils are currently undergoing intensive development, particularly in the vicinity of Popondetta. The main crops being planted are cacao and robusta coffee.

The Islands of Papua and New Guinea.

New Britain.—New Britain can be sub-divided longitudinally into two distinct soil regions separated by mountain ranges which are composed principally of metamorphic rocks intruded by igneous rocks. To the north lies a belt of recent volcanic deposits, forming an almost continuous line, while to the south is an area of Upper Tertiary and Pleistocene raised coral limestone together with some Upper Tertiary sediments. The limestones approach the northern coastline west of Talasea. The recent volcanics have given rise to pumiceous material, free draining and fertile but in which only the earliest rudiments of pedological development are discernible.

These pumiceous soils have been extensively planted to coconuts and cacao, particularly on the Gazelle Peninsula, which is the most intensively developed part of the Territory and the major production area for these crops.

Yellow clay loams and clays have formed from the limestones. Karst phenomena in the western areas have resulted in excessively drained soils. The remainder of the area has excessively high rainfalls with resultant severe leaching.

New Ireland.—The geology of this island is dominated by the raised corals of Upper Tertiary age which occur on the east coast for three-quarters of the length of the island. On the west coast is a narrow fringe of Pleistocene volcanics which expand in the south-east and widest part of the island, in which also occurs an area of Upper Tertiary sediments. Two soil types are found on the raised corals. On the hard corals adjacent to the coast, shallow red brown clays and clay loams occur with characteristics similar to those of a *terra rossa.* Further back on the older softer corals, yellow brown clays and clay loams have been developed. Both soils are acid throughout the profile and the yellow brown soils are markedly deficient in potassium. The red brown soils tend to be subject to drought owing to their shallow depth and free drainage and the fissured coral underlying them.

The volcanics give red brown laterized clays. A small though significant area of coral sands also occurs as inclusions along the coast.

These soils are all suitable for coconut production, with the reservation that the potash-deficient yellow-brown soils will not support a long-lived or highly productive stand without fertilizer. The east coast area is fully planted.

Manus Island consists of Pleistocene volcanics and recent raised coral. The soils on the volcanics are red laterized clays and clay loams and by virtue of the topography are often shallow and eroded. The coconut is the main economic crop.

The Solomon Islands.—Bougainville is essentially of recent volcanic origin with the exception of recent raised coral reefs in the north. Although the volcanics are mainly andesitic in character, a considerable diversity of soils has arisen from them. The range is from brownish-yellow clay-loams with a well-developed profile, through tuffaceous shallow soils with pyroclastic characteristics in the parent material, to coarse mineral sands similar to the occurrences on the north coastal areas of Papua–New Guinea. Pumiceous soils similar to those in New Britain are also found.

Extensive plantation development has taken place along the north and east costs, with coconuts on the coral derived soils and coconuts and cacao on the volcanics.

Buka Island is geologically of recent origin. The east coast consists of raised coral giving rise to orange clays of only moderate fertility. Similar soils are found under the same conditions in the north of Bougainville. On the west coast there are volcanics with soils having the same characteristics as the more mature profiles of similar origin in Bougainville. Limited coconut and cacao planting has taken place on these soils.

The D'Entrecasteaux Islands and Louisiade Archipelago.—The D'Entrecasteaux group consists of metamorphics and Pleistocene volcanics intruded in many places by granites and granodiorites. The acid character of the metamorphic and igneous material gives rise to sandy clays which are often shallow because of the erosion occasioned by the generally steep topography. Limited areas of raised coral have developed shallow Rendzina-type soils.

Trobriand and Woodlark Islands.—These islands consist of Pleistocene raised coral with some igneous intrusions on Woodlark Island. There is no significant plantation development on these islands although some coconuts are grown.

AGRICULTURAL EXPORTS.

Agricultural production in the Territory of Papua-New Guinea was seriously disrupted by the Second World War. Most plantations were abandoned for periods of up to 10 years and an appreciable number devastated either by deliberate action, where airstrips were constructed or areas converted to food production, or consequentially, following fighting in plantation areas. However, the rehabilitation of overgrown areas coupled with new planting was greatly stimulated by high prices in the post-war decade and pre-war production of all export commodities has now been substantially exceeded, the increase being spectacular in some instances.

Copra and other coconut products, which formed the bulk of pre-war agricultural exports, still occupy a dominant position but other products of minor pre-war importance have grown rapidly and cocoa has recently pushed rubber out of second position in export values. Rubber had held this position for many years previously. Another factor of increasing significance since the Second World War is direct participation in cash cropping by the indigenes. In pre-war days such participation was nominal except with copra, whereas currently at least one-quarter of each of the three crops copra, cocoa and coffee is produced by the indigenes and their proportion of production is increasing. This development has been guided and supervised closely by the Agricultural Extension Service which has also given attention to the quality of native produce.

Each of the leading exports, namely coconut products, cocoa, rubber and coffee, will be discussed.

Coconut Products.

In the early post-war years, almost the whole of Territory coconut production was exported as copra. The only other product exported before 1950 was dessicated coconut; in the peak year, exports of this commodity reached almost 3,000 tons, but production has since ceased. A significant change has occurred since 1950 with the erection at Rabaul of an oil seed crushing mill, which has in recent years crushed up to one half of the copra produced in the Territory of New Guinea, so that exports of oil and coconut cake have assumed considerable and increasing significance.

Figure 5 shows the trend in exports of coconut products over the last decade. For comparison, pre-war exports did not exceed 80,000 tons and it was four years after the war before production returned to half this figure. Fluctuations during the last five years have been brought about more by the state of stocks of coconut oil at Rabaul than by real annual variations in production and there is, in fact, a steady rising trend in production of about 2 per cent. per annum. Coconut production is concentrated particularly in the Territory of New Guinea, especially the New Guinea islands.

Prices during the 1959–60 season were highly satisfactory, rising to an all-time high in the middle of the year. The average price for copra was a record at £93 8s. per ton with the value of oil and cake in proportion. The year closed, however, on a lower note with an accelerating rate of fall in values.

Cocoa.

In the pre-war decade, efforts were made to establish a cacao growing industry to relieve dependence of the agricultural industries of the Territory on a single crop. Although production never exceeded 400 tons before the war, the new industry had nevertheless made a sound start. Most of the cacao plantations were lost by direct or consequential war damage but there was an early post-war revival of interest with the stimulus of very high prices. Figure 6 shows the spectacular advances in cocoa production during the last decade. Production is so far almost totally confined to New Guinea with current production in Papua under 100 tons per annum. Fairly extensive plantings made in Papua on alluvial soils have been disappointing but promising new areas are now coming into production on volcanic soils in Northern Papua and it is anticipated that Papuan exports will begin to assume significance in the next few years.

The average price for cocoa beans in 1959–60 was satisfactory at £280 per ton, although the lowest for four years. However, the year closed on a sustained downward trend and estimated world production is such that this trend is likely to continue.

Coffee.

Pre-war coffee production was about one-half Lowland Robusta coffee and one-half Highland Arabica and total production did not exceed 100 tons per annum. Since the war, however, the main Highland valleys, which were barely contacted and not fully explored pre-war, have been opened up, and great interest has developed in the production of Highland Arabica coffee, particularly in view of the extremely high prices prevailing during the period of world coffee shortage up to about 1956. Pre-war Robusta areas have not been rehabilitated but over the last three years some post-war Robusta plantings have come into production in both Papua and New Guinea. Much of this Robusta planting is Native.

All except about 50 tons of present exports are New Guinea Highland Arabica. The production over the last decade is shown in Figure 7 which demonstrates the extremely rapid growth of the industry. In view of the world coffee situation, some difficulties may be experienced in marketing when production exceeds Australian consumption but the high quality of the product will assist in finding market outlets. The average price achieved in 1959–60 was satisfactory at £458 per ton and, temporarily at least, the market appears to be fairly stable.

Rubber.

The whole of the Territory's rubber production comes from Papua. There are many areas suitable for rubber growing in New Guinea but the industry there was off to a bad start about 40 years ago when the planting of *Ficus* rubber was commenced in preference to *Hevea.* With the falling off in demand for *Ficus* rubber, interest in other rubber-producing plants was not sustained in New Guinea.

Pre-war rubber production in Papua was below 2,000 tons per annum and it took some years after the war to find and train sufficient tappers to regain that level of production. In the last decade, as shown in Figure 8, production has risen steadily and is now more than twice the pre-war figure. However, very little of this production comes from post-war plantings and much of the expansion has been brought about by the full exploitation of pre-war plantings as they have matured. Present planting and replanting rates are such that acreage is not increasing greatly but over-age areas are being progressively replaced with new high yielding grafted clones or clonal seedlings so that present production could double without any increase in the area planted.

Prices in 1959–60 were the highest for five years and averaged 3s. 2d. per lb. for smoked sheet, but the year closed on a falling note.

Other Agricultural Exports.

There are numerous products exported in a small way but peanuts and passionfruit juice are worthy of specific note. Peanut exports in 1959–60 reached 1,844 tons, mostly from the Territory of New Guinea. In the previous year, the figure was 1,703 tons but prior to that exports were relatively small. The market price at £150 per ton was satisfactory but future marketing prospects are uncertain.

Passionfruit juice production is more or less stable at around 400,000 lb. per annum valued at approximately 4s. per lb. All passionfruit production is in the Highlands of New Guinea and in Native hands. Production could easily be raised but further outlets would have to be found as present production is the maximum which can be absorbed by known markets.

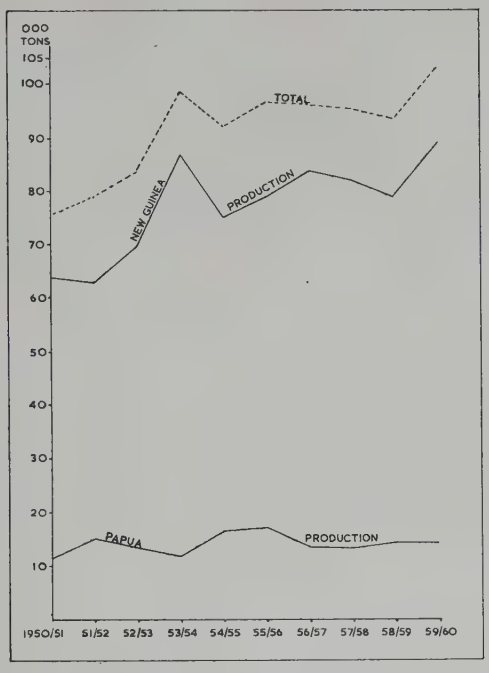

FIGURE 5—*Coconut Products.*

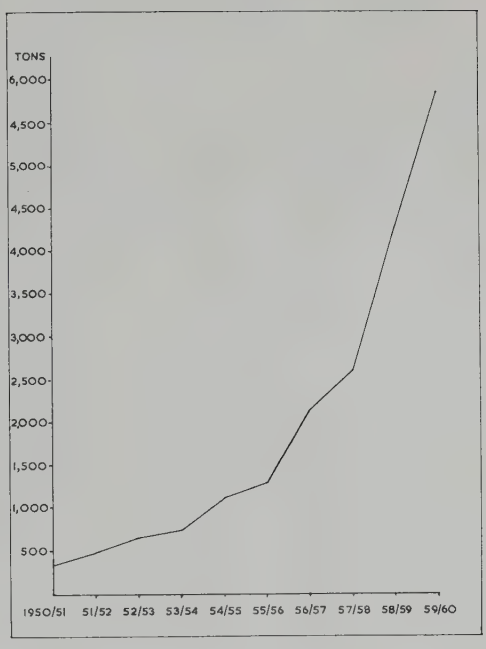

FIGURE 6—*Cocoa.*

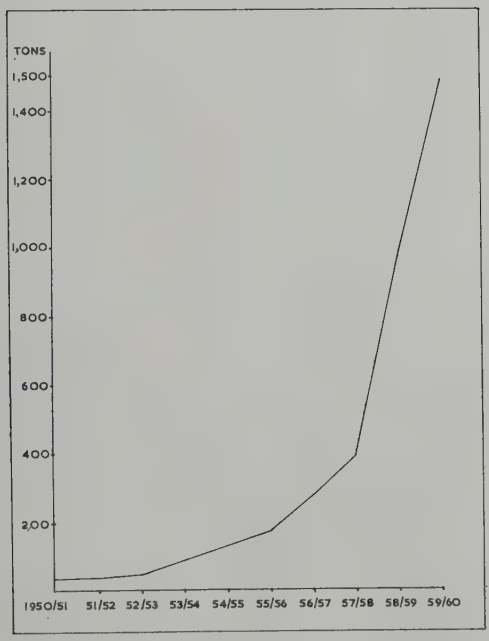

FIGURE 7—*Coffee.*

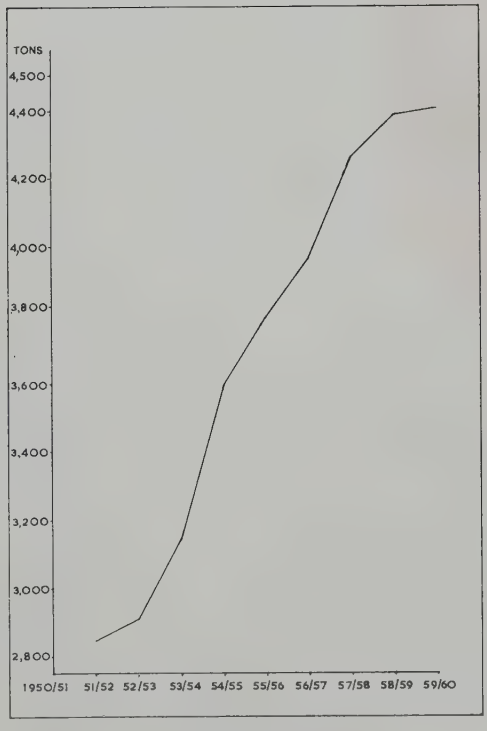

FIGURE 8—*Rubber.*

The leading agricultural exports from the Territory of Papua and New Guinea, 1950-1960.

FISHERIES EXPORTS.

There is no significant export of edible marine products from the Territory, the whole of production being consumed locally. However, there are appreciable exports of shell and crocodile skins and in the peak year of 1955–56, the combined export value was nearly £500,000.

Shell.

The three types of shell exported are trochus, green snail and mother of pearl.

Trochus.—Exports in 1959–60 were 6,831 cwt. valued at £92,621. About two-thirds came from New Guinea and the remainder from Papua. This is the most important shell of commerce in Papua-New Guinea and until 1957–58 exports were in excess of £250,000. Since the war the world market for trochus had risen steadily year by year until in 1957 for the first time overseas buyers reported a drop in price, from £600 sterling to approximately £400 sterling per ton. Trochus was mainly used in the button trade and high prices had placed this item outside the market. More and more manufacturers of buttons all over the world commenced switching to plastic substitutes and in 1955 imports of trochus into the American market ceased. By late 1957 the price had dropped to around £300 per ton. However, in late 1958 the market recovered slightly and until the end of February, 1959, there was a market for trochus at about £300 to £320 per ton. Since then there has been a considerable falling off in demand with prices around £265 to £275 per ton, with little interest shown by buyers, and a further drop in price is anticipated.

Green Snail shell.—From 1955–56 when exports of this commodity were valued at £80,643, there has been a marked decline in value until the end of the current year when export values rose slightly to £13,793. As with trochus, the high price per ton has resulted in the substitution of synthetics with consequent fall in production and revenue.

Pearl shell.—During the last five years, with the exception of 1957–58, the value of exports has remained relatively stable at a low level. Owing to competition of synthetics, the value of exports fell from £7,995 in 1957–58 to £2,520 in 1958–59. This year, better quality shell resulted in a slight increase in export value to £3,565. Fishing for mother of pearl is only intermittent in the Territory and results have not been very promising. The Territory pearl oyster beds are evidently characterized by a sharply shelving bottom and strong tidal streams, two factors which do not lead to easy commercial development.

Crocodile skins.

There has been little change in the returns for the export of this item over the past five years. In 1955–56, the value was £53,887 and in 1959–60, £64,880. In 1955 the market price for first class skins was 6s. per inch and at the end of the present year, the price had risen to 9s. per inch. This increase in price over the past five years has more than offset the decline in the number of crocodiles available. Of the total exports for 1959–60, £21,360 came from Papua and £43,520 from New Guinea. The majority of the skins were obtained from the two largest rivers, the Fly and the Sepik, and their tributaries.

DEPARTMENT OF AGRICULTURE, STOCK AND FISHERIES.

ORGANIZATION.

The Department of Agriculture, Stock and Fisheries, contains four technical Divisions, namely Animal Industry, Plant Industry, Extension and Marketing, and Fisheries. There is also a Headquarters Division comprising mainly administrative and clerical staff.

The Division of Animal Industry has the responsibility for research and services with the livestock of the Territory. The principal types of livestock are British breeds of cattle owned almost entirely by Europeans and pigs and poultry owned by the indigenous inhabitants. The main functions of the Division are as follows:

(i) The promulgation and administration of animal quarantine legislation.
(ii) The maintenance of quarantine programmes and supervision over internal and external stock movements.
(iii) The provision of clinical and advisory veterinary services to stock owners.
(iv) The planning and conduct of programmes of disease and pest eradication and control.
(v) Investigations on animal pest and disease problems.
(vi) Selection and breeding of stock adapted to Territory environments.
(vii) Services and research in animal husbandry.

The Division operates Experiment Stations where it carries out research and breeds livestock for distribution. There are supporting laboratories with modern equipment to handle all aspects of parasitology, bacteriology and pathology.

The Division of Plant Industry is responsible for research and investigational work into all aspects of agriculture. Specialist technical sections, with the exception of those engaged in livestock research, are attached to this Division and laboratories are located at strategic centres throughout the Territory. The Division operates a number of Experiment Stations located in representative environments and is decentralized, with the majority of staff working on the various Experiment Stations throughout the Territory. The main activities are as follows:

(i) The promulgation and administration of plant quarantine legislation and legislation to control outbreaks of pests and diseases and noxious weeds.
(ii) Plant introduction and testing of new crops and new varieties of economic plants.
(iii) Crop improvement and agronomic experiments with all crops grown in the Territory.
(iv) Services and research in plant pathology and economic entomology.
(v) Chemical and biochemical services and research.
(vi) Soil and land use surveys.

The Division of Extension and Marketing has the following functions:

(i) Agricultural patrolling and village contacts to encourage indigenous landholders to adopt improved methods of production with subsistence and cash crops.
(ii) Distribution of planting material of subsistence and cash crops.
(iii) Agricultural training up to Agricultural College level.
(iv) Maintenance of Extension Stations and Centres for—
  (*a*) training of lower level intermediaries;
  (*b*) demonstration of crop husbandry and processing techniques;
  (*c*) local experimentation and adaptability trials;
  (*d*) seed production, especially the production of pure seed of crops of local importance.
(v) Promotion of improved types of rural organizations.
(vi) Supervision of processing of economic crops and operation of central processing facilities where required.
(vii) Assistance with the marketing of agricultural produce where satisfactory normal marketing channels are not available.
(viii) Operation of district mechanization services and area workshops.
(ix) Production inspection services.

The most important activities of the Division may be summarized by saying that it has the task of extending to producers the results of investigations carried out by the other Divisions of the Department and assisting producers, both Native and European, to apply better techniques to the production, processing and marketing of their crops. The service is available to Europeans and Indigenes alike but because of the great predominance of Native agriculturalists and their generally primitive state, the main emphasis falls on Extension and Marketing services to Native people.

The Division of Fisheries has the following responsibilities:

(i) The promulgation and administration of Fisheries' legislation.

(ii) The introduction of improved fishing techniques to indigenous fishermen and the distribution of fishing gear.

(iii) The training of fishermen ashore and afloat in all aspects of fishing.

(iv) The encouragement of the indigenous people to organize their activities and increase their consumption and trade in fish.

(v) Investigation of potential fishing grounds and the encouragement of commercial fishing where this does not conflict with subsistence requirements.

(vi) Promotion of fresh water fish production.

(vii) Investigations into economic and marketing aspects of the fishing industry.

(viii) Institution of a Fisheries' inspection system.

The Division will shortly establish a Marine Biological Station to support all aspects of its work. It operates a research vessel, engaged primarily in testing potential trawling grounds, and several smaller auxiliary vessels.

DIVISIONAL REPORTS.

DIVISION OF ANIMAL INDUSTRY.

VETERINARY SERVICES.

Disease Eradication.

Cattle Tick (Boophilus microplus).

Central District.

Following eradication spraying programmes in 1958–59, re-infection occurred on all six properties in the Port Moresby area of the district. All properties are now under three-weekly control spraying programmes until conditions are suitable to recommence eradication.

The breakdown in the eradication in this area is considered to be a result of the presence of wild horses and deer, both of which can act as hosts of the cattle tick. Control sprayings will serve to lessen pasture infestation while attempts are made to eliminate the wild horses and drive the deer away from the pastoral areas. Studies in the bionomics of the cattle tick in this area have shown that although the deer can act as a host for the cattle tick, it is not favoured and considerable larval mortality occurs when it is the only host available. The reduced pasture infestation from the control programme may eliminate the deer as an effective host.

The Sogeri area of the Central District has remained cattle tick free.

Morobe District.

Spraying programmes continued on properties in this district. On one, the programme was completed, while the composite spraying of small herds at the Division's Animal Industry Centre, Three Mile, Lae, continued. On one property which completed its eradiction spraying programme in 1958–59, no ticks have been found during regular inspections. However, musters have been incomplete and the property must remain suspect until complete musters show otherwise. The majority of herds in the district are tick free.

New Britain District.

All herds were regularly inspected and remained tick free until May, 1960, when an infestation was discovered on two adjoining properties in the Kokopo area. An investigation into the reasons for the infestation led to no firm conclusions. There had been no suspect

movements of horses or cattle on to the properties. The only suggestion advanced for the outbreak was the movement from the Warangoi area of native-owned dogs which could have brought in ticks from wild cattle suspected to be present in that area.

All herds in this area had been free for a minimum of two years before this outbreak. A programme of spraying with eradication as its aim was instituted on the two affected properties.

Highlands Districts (Eastern, Western and Southern).

An eradication spraying programme which was commenced in the Eastern Highlands as a result of infestation from imported cattle in 1958–59 was completed. The two affected properties have remained clean since the completion of spraying but the twelve-month inspection period is not yet complete. The rest of the Highland Districts has remained tick free.

Madang District.

Herds in the immediate vicinity of Madang have continued under spraying programmes. A re-infestation occurred on three properties and, as a result, an 18-month spraying programme has recommenced. This re-infestation occurred as a result of the presence of buffalo which resisted attempts at mustering. The owners have been asked to destroy these animals because they are prejudicial to the success of the programme in the Madang District. Properties have completed spraying programmes and have remained clean during inspections although further inspections are necessary.

The general tick situation is summarized in Table 1.

TABLE 1.—ANALYSIS OF RESULTS OF THE CATTLE TICK ERADICATION PROGRAMME.

District.	Cattle Treated each Week.	Horses and Donkeys.	Holdings Under Treatment.	Holdings re-infested.
Central*	1,698	96	6	..
Morobe	502	80	2	1 unfinished
New Britain	120	7	2	2
Highlands	26	5	2	Nil
Madang	963	49	17	3
Total	3,309	237	29	5

* Control treatments each three weeks.

Cattle tick eradication spraying is carried out on a weekly basis. Two insecticides—D.D.T. and Diazinon—are used alternately, each for an eight week period, the treatments being carried out for eighteen months. All treatments are carried out under the supervision of a Departmental Stock Inspector and the owner is responsible for full musters of his stock.

A new organic phosphate insecticide " Asuntol " has recently been introduced into the control programme in the Central District where it was suspected that a D.D.T. resistance was developing. This insecticide has proved an advantage on the affected property.

Tuberculosis.

Testing has been maintained wherever Veterinary Officers have been stationed. Testing has also been carried out in the Madang District by a visiting Veterinary Officer.

TABLE 2.—ANALYSIS OF TUBERCULOSIS ERADICATION PROGRAMME.

District.	Animals Tested.	Reactors.	Properties Tested.	Properties Affected.	Per cent. Reactors.
Central	929	Nil	10	Nil	0
Morobe	2,593	27	20	6	1.4
New Britain	1,536	Nil	12	Nil	0
Highlands	3,400	10	24	5	0.3
Madang	920	5	8	2	0.54
Total	9,378	42	74	13	0.44

Brucellosis.

The preliminary survey for this disease has now been completed in the Central, Morobe, New Britain and Highlands Districts. Further testing in these districts will be restricted to the infected properties except that an annual check test will be made on all properties.

TABLE 3.—ANALYSIS OF BRUCELLOSIS ERADICTION PROGRAMME.

District.	Sera Tested.	Reactors.	Properties Tested.	Properties Affected.	Per cent. Reactors.
Central	1,512	3	10	2	0.2
Morobe	2,642	57	13	1	2.16
New Britain	1,799	8	12	1	0.44
Highlands	1,210	Nil	3	Nil	0
Total	7,163	68	38	4	0.95

Disease Control and Investigation.

This function of the Division is centred around the Central Veterinary Laboratory, Port Moresby. Samples for confirmation of field diagnoses are received from Veterinary Officers and Stock Inspectors. All samples for the agglutination test for *Brucella abortus* infection are also tested in the laboratory.

Diseases of Cattle.

Diseases diagnosed in cattle during the year included:

Tuberculosis.

The position is reported above:

Brucellosis.

The position is reported above.

Ephemeral Fever.

There have been no further cases of this disease since the outbreak in March to July of 1959. The disease was localized to the Port Moresby and Sogeri areas of the Central District of Papua. The disease followed the introduction of cattle from North Queensland and the morbidity was low at 25–30 per cent. of obvious clinical cases in a supposedly non-resistant population. The mortality of 1 per cent. of the population was slightly above normal.

Papillomatosis.

Cases appear sporadically throughout the Territory. Large warts may be knocked off and the resulting wound becomes attractive to the screw worm fly.

Listeriosis.

Organisms closely resembling *Listeria monocytogenes* have been isolated from the brains of cattle from two properties in the Sogeri area of the Central District. The clinical picture has been one of sudden death with only one of the animals being seen pre-mortem. This case showed signs of encephalitis. Nine animals died on one property and one on the other.

Haemorrhagic Septicaemia Syndrome.

This syndrome has been seen sporadically in the Sogeri area of Central District. When it occurs as a herd disease it affects cattle recently imported into the area. When individual animals within a herd are affected they are most frequently animals 1–2 years of age. Losses in introduced animals have been as high as 75 per cent. In most cases animals are found dead although clinical signs of elevated temperature (105°–108.4°), increased respiratory and heart rate, clear nasal discharge, the passage of hard faeces and terminally the passage of dark red urine have been noted in affected mobs.

Bacteriologically, the field is invariably obscured by post-mortem invaders. On occasions an organism resembling *Pasteurella multocida* has been isolated. The disease has not been transmitted to experimental cattle by inoculation although a febrile reaction lasting 2–3 days was produced in one animal.

Reproduction of the disease may have been complicated by the fact that locally bred animals used in tests may have had an immunity through previous contact with the disease.

Pasteurella boviseptica vaccine from the Commonwealth Serum Laboratories was used prophylactically in a mob of heifers imported into one Administration station. Although an outbreak of the syndrome occurred, the losses were fewer than in previous outbreaks.

Infectious Keratitis.

The organism *Moraxella bovis* has been diagnosed in cattle imported into the Territory. The condition responds to chloromycetin ophthalmic ointment.

Mycotic Dermatitis (*Streptothricosis*). Sporadic cases of this disease occur throughout the Territory. The organism *Nocardia dermatonomus* has been cultured in some cases. This disease was a herd problem on one property running Shorthorns in the Central District about 5–6 years ago. About 80 per cent. of calves born into the herd were affected and died. This herd problem has not been seen since.

Coccidiosis.

This has been diagnosed in cattle in the Central and New Britain District.

Helminth Infestation.

Helminth parasites represent a hazard to cattle production in the Territory because of the optimum temperature and humidity conditions for non-parasitic stages. The parasites which are most important economically are *Haemonchus placei*, *Trichostrongylus axei*, *Bunostomum phlebotomum*, *Bosicola radiatum*. The liver fluke *Fasciola hepatica* has been identified in cattle herds in the Highland districts, particularly where they are associated with sheep.

Prophylactic drenching of weaner stock is recommended as a routine. The observed weaner unthrift on many properties in the Territory could be partly the result of the worm burden which they carry.

Cattle Tick (Boophilus microplus).

The position with regard to this parasite has been mentioned above. Other ticks have also been recorded on cattle in the Territory, particularly *Haemaphysalis* spp. which are present on native fauna.

Buffalo Fly (Siphona exigua).

This pest occurs on plantations in the Kokopo area of the New Britain District. Eradication by spraying of all animals at weekly intervals for eight weeks was attempted but re-infection occurred three months after completion of the programme. Plantations at a greater distance apart than the stated range of the Buffalo Fly have been treated. Future treatments must include all animals in the affected area if the eradication is to be a success. Control treatments are being carried out at present.

Screw Worm Fly (Chrysomyia bezziana).

This parasite is endemic to the Territory. It is most severe in coastal areas and at heights above 4,500 feet the incidence of strikes is very much reduced.

Prophylactic treatments with dieldrin at intervals of 4–6 weeks and the treatment of strikes with the Screw Worm Smear EQ.335 effect adequate control. This parasite makes it necessary for cattle to be run on a more intensive scale than in Australia. Routine station procedures such as branding and castrating must be carried out in periods of decreased fly activity or when the incidence is reduced by regular spraying. The animals must be kept under close observation until the wounds are healed to the stage where they are no longer attractive to the fly. Treatment of these wounds with EQ.335 provides good protection. Similarly, new born calves should be treated to prevent navel strike. A new organic phosphate insecticide with a long residual effect (Asuntol) has recently been obtained and is under trial. Preliminary observations have shown its efficacy but further trials are continuing.

Iodine Deficiency.

A herd of cattle at Kokoda in Northern District of Papua is suspected to be suffering from an iodine deficiency. Stillborn and hairless calves have been seen and at least one clinical case of enlargement of the thyroid has occurred. Potassium iodide treatment corrected this enlargement. Lowered fertility and failure to thrive are also associated with this herd.

Phosphorus Deficiency.

A limited number of serum phosphorus estimations suggests that phosphorus deficiency may occur in some areas. A complete survey is necessary in suspect areas.

Plant Poisoning.

Cycas circinalis is seen throughout the Territory and ingestion of this plant causes an inco-ordination in the hind quarters of affected cattle. Cattle would appear to take a liking to the plant and selectively graze it even where there are only a few specimens. Its elimination from all pastoral areas is recommended. The problem is difficult because of its ability to recover after cutting and the longevity of seeds.

Other plants suspected as causes of stock losses during the year were:

(i) *Crotalaria* spp.—Many species of this genus are toxic to livestock. *C. goreensis* is thought to have caused liver damage and death in one herd. *C. mucronata*, reported to be highly toxic, is present in parts of the Territory but as far as is known has caused no toxic effects. *C. anagyroides* has been used in trials on one station as a sheep and cattle fodder with no apparent ill effects.

(ii) *Aeschynomene indica.*—Plants in the fruiting stage are reported to be poisonous. The death of three animals was recorded on one property after grazing a paddock where fair numbers of this plant in the early fruiting stage were growing. The plant had been grazed. The animals died while being driven and several others were affected but recovered. Post-mortem examination of one carcase was made after considerable delay. It was inconclusive because of decomposition but lesions were similar to those caused by heat exhaustion.

(iii) *Salvia plebia*, a nitrate concentrator, has caused the death of calves with symptoms of nitrate poisoning. *Asclepias curasavica* is suspected of causing deaths in several areas.

Infertility.

Infertility is included as a problem which affects many herds throughout the Territory but which may have one or several causes. The first step in its investigation has been completed since Brucellosis can no longer be regarded as a serious cause of infertility.

Differential studies on fertility of types of recognized heat-tolerant breeds and of British breeds in the same environment are being carried out and will further our knowledge of the effect of adapted breeds on the problem.

Other factors which will be investigated include the possibilities that mineral deficiencies (phosphorus, iodine, cobalt, copper) may be involved, that the inadequacy of protein and Vitamin A in natural pasture leads to a deterioration of semen quality and that Vibriosis and Trichomoniasis may occur.

Diseases of Horses.

Diseases diagnosed in horses during the year include:

A Horse Disease in the Markham Valley (Morobe District).

Over the past five years about twenty horses have died in the Markham Valley (Morobe District) after showing symptoms of flatulent colic. Records of outbreaks which occurred prior to the posting of the present Veterinary Officer to the district are available only through questioning residents. These reports suggest symptoms of severe abdominal pain, distension of the abdomen and rapid death. The majority of the animals were grazing on unimproved natural pasture in which Kangaroo grass (*Themeda* spp.) and Kunai (*Imperata* spp.) dominate. Five deaths occurred while animals were grazing on improved pasture in which *Centrosema* was dominant.

Three possible causes of the disease have been advanced, namely, flatulent colic, grass sickness, and ingestion of toxic substances in the pasture. Flatulent colic could be suggested as the cause of the disease of the horses grazing on the improved pasture since it usually follows the ingestion of highly fermentable feeds. The affected horses evidently consumed large quantities of *Centrosema* in a reasonably short time. The other cases on unimproved natural pasture would not fit into this pattern so easily since Kangaroo grass and Kunai pastures are considerably fibrous and are not highly fermentable. Grass sickness has been described only in Europe. The aetiology is uncertain although symptoms and lesions seen in the Markham Valley are very similar to those of acute grass sickness. Progress towards correlating the two diseases must necessarily await further outbreaks of the disease so that histological examination may be made of sympathetic ganglia which show specific lesions in grass sickness.

Botanical investigation of affected pastures has indicated some suspect plants although there has been no one plant which could be constantly incriminated. Feeding of suspect plants to guinea pigs has been undertaken but results are inconclusive.

No outbreaks have been observed since December, 1959.

Tetanus.

Cases have been observed throughout the Territory. Prophylactic vaccination with tetanus toxoid has been carried out on most Administration stations and on other properties when requested.

Helminth Infestation.

As in cattle, helminth parasites are a common cause of poor condition in horses. Those of importance are *Parascaris equorum* in foals and *Strongylus* spp. in adults. One case of fatal peritonitis resulting from migrating *Strongylus* spp. was recorded. Treatments with piperazine for Ascaridiasis and phenothiazine for Strongylosis are recommended.

Dermatitis.

Dermatitis is experienced in horses throughout the Territory. Several causes have been enumerated. The most common are allergic reactions to insect bites (Queensland itch), infection with trombiculid mites and ingestion of *Leucaena glauca* (mimosine poisoning).

The condition is alleviated in the first two instances by treatment with insecticides, preferably those with residual effects, organic phosphates being better miticides. In the third case the removal of the horse from areas where *Leucaena glauca* grows will effect considerable improvement.

Excessive Wound Granulation.

Conditions akin to swamp cancer are seen when wounds occur mainly on limbs, especially in areas of high rainfall and humidity. The condition is exaggerated by the constant attention of the small bush fly (*Musca vetustissima*) to the granulating areas and the ever-present threat of screw fly infection. Cauterization with $CuSO_4$ and treatment with screw worm smear EQ.335 have shown some success.

Wounds and Sprains.

These are common in working horses and animals used for racing and polocrosse.

Diseases of Pigs.

Diseases diagnosed in pigs include:

Anthrax.

This disease is endemic among native pigs in the Eastern, Western and Southern Highlands. It is not seen outside these districts and there is a prohibition of the movements of pigs from the Highlands to other parts of the Territory. Outbreaks are reported regularly and in one instance over 600 deaths were reported. Vaccination with McGarvie Smith spore vaccine is carried out by officers of the Division and also by Extension Officers. Vaccinations appear to arrest the outbreaks and Natives are becoming more aware of their advantages. Controlled field trials of vaccination have been unsuccessful because of the lack of co-operation of Native owners and their reluctance to have a permanent identification mark placed on their animals. They consider a mark to be a sign of an Administration claim on the animal.

A preliminary investigation into the organism has shown its non-pathogenicity for other domestic animals. Guinea pigs are highly susceptible. Full details of the investigation are recorded in a paper in preparation.

Pneumonia among Native-owned Pigs.

This has been investigated by Veterinary Officers in New Britain and the Highlands Districts.

New Britain.—The survey was carried out in conjunction with inspections of pigs slaughtered for the supply of pork to the town of Rabaul. It is thought that the predisposing cause of pneumonia in this area is infestation with the pig lungworm *Metastrongylus* spp. During the survey, 1,457 pairs of lungs were inspected with 1,213 of these being infested with *Metastrongylus* spp.—an incidence of 83.25 per cent. A reduction in incidence can be effected only by an improved husbandry technique whereby pigs are not allowed access to the common earthworm which is the intermediate host of the parasite.

Highland Districts.—The pig lungworm is also prevalent in these districts, although bacterial infections seem to be the chief cause of death. Treatment with sulphamezathine will frequently effect a recovery. It is considered that virus pneumonia of pigs is almost certain to be present throughout the Territory. It is overshadowed by helminth and bacterial infections in Native-owned and some European-owned pigs but should show up in Departmental piggeries when growth rate and feed conversion studies are undertaken.

Erysipelas.

Swine erysipelas has been diagnosed in one commercial piggery in the Central District. The disease has been seen in acute, sub-acute and chronic forms. Diamond skin disease was present in one litter. Post-mortem lesions and bacterial culture confirmed the diagnosis. Pigs may be moved from this piggery only for slaughter, and vaccination will be carried out.

Coccidiosis.

A diagnosis of coccidiosis was made in pigs on a property in the Morobe District, following the demonstration of *Eimeria scabra* in faecal smears. Losses in weaned pigs were up to 18 per cent. Improved diet and hygiene with treatment with specific drugs stopped the outbreak.

Helminth infestation.

Helminthiasis in Native-owned pigs is a major factor in the poor growth and production of these animals. Almost any Native-owned pig shows a complete picture of the range of worm parasites present in the Territory. Migrating helminth larvae would be another predisposing cause of the pneumonia mentioned above. The parasites commonly encountered are:

Ascaris lumbricoides suum
Macracanthorynchus hirudinaceus
Necator spp.
Oesophagostumum dentatum
Physocephalus sexalatus
Stephanurus dentatus
Trichuris trichiura.

In pigs kept under more intensive systems, the parasites of major importance are *Ascaris lumbricoides suum*, *Necator* spp. and *Stephanurus dentatus*. Best results are obtained when pigs are restricted completely to concrete pens. In this way *Stephanurus* infection is reduced considerably and the only serious worm problem is *Ascaris* infection which can be controlled with piperazine.

Posterior paralysis is a common sequel of *Stephanurus* infection.

Agalactia.

Cases are seen when sows are run under conditions of inadequate nutrition. If treatment is not provided quickly, the litter is lost although the sow may recover.

Piglet Anaemia.

Iron deficiency anaemia is seen in piglets reared on concrete without the provision of adequate iron supplements.

Vitamin A Deficiency.

This condition is seen in pigs even when green feed is supplied. It is considered that green feed is an unreliable and generally inadequate source of Vitamin A and it is recommended that an additional source of stabilized vitamin A be provided as a routine.

Insecticide Poisoning.

Dieldrin has been incriminated in the death of young pigs where piggeries have been sprayed with the insecticide to reduce fly populations.

Diseases of Poultry.

Diseases diagnosed in poultry include:

Fowlpox.

This disease is present throughout the Territory. Vaccination has been carried out in some instances although the disease is often sporadic and self-limiting. Losses of up to 90 per cent. have been experienced in turkey flocks.

Avian Monocytosis (*Uraemia*).

A disease outbreak in a large commercial poultry flock at Port Moresby has been diagnosed as Avian Monocytosis or Uraemia. It affected chickens from eight days of age; treatment by the addition of potassium to the diet seems to have reduced its incidence. The ready transmission of the disease supports the virus aetiology theory of Avian Monocytosis.

Leucosis.

This disease has been confirmed histologically in chickens and has been seen throughout the Territory.

Botulism.

On clinical signs and post-mortem lesions, botulism has been diagnosed in several parts of the Territory. In one outbreak, filtered intestinal contents from affected ducks killed guinea pigs on inoculation. Up to 15 per cent. of birds died before the outbreak was controlled by improved hygiene.

Aspergillosis.

The disease was diagnosed on one commercial poultry farm in one batch of chickens imported from Australia.

Coccidiosis.

The widespread use of recommended coccidiostats has overcome the problem in flocks under good conditions of hygiene and nutrition.

Helminth Infestation.

The helminths most commonly recorded are:

Acuaria hamulosa
Ascaridia galli
Capillaria spp.
Heterakis gallinae
Oxyspirura mansoni
Raillietina tetragona.

Most infections are readily controlled by medication.

Vitamin A Deficiency.

This is the most prevalent nutritional disorder seen in poultry. Green feed, as with pigs, seems an unreliable and inadequate source of Vitamin A. Supplements of Vitamin A powders or emulsions are recommended to alleviate the condition.

Pullorum.

This disease was diagnosed in Native-owned poultry immediately following the war. Because commercial hatching of chickens is not carried out in the Territory the disease is not of major importance. All day-old chickens imported must be drawn from within pullorum eradication schemes operated by State Departments of Agriculture. It is intended to commence limited surveys throughout the Territory to determine its present incidence.

SLAUGHTERING AND MEAT INSPECTION.

Veterinary Officers and Stock Inspectors are responsible for the maintenance of slaughtering and meat inspection services. At present all slaughtering is carried out in small private slaughter-houses that must comply with minimum requirements. This decentralization, as well as being inconvenient for the maintenance of adequate inspection services, is wasteful of important by-products of the cattle industry. Proposals are being considered for a central meat processing works and it is felt that the establishment of such a works will be the impetus needed for the widespread development of the cattle industry.

Central District.

Slaughtering for supply to Port Moresby is regularly carried out in two private slaughterhouses. One of these is of modern construction using all-electric equipment and includes a digester for the utilization of offal and condemned carcases.

During the year, 292 cattle and 90 pigs were inspected. There were no carcase condemnations although some minor disease processes caused condemnation of offal, particularly from pigs. One tuberculous gland was recovered from an imported bullock. Histological and bacteriological examination confirmed the inspector's diagnosis.

Morobe District.

Cattle for human consumption are slaughtered regularly at Lae, Wau, Bulolo and Zenag. The carcases from Bulolo and some from Lae are not for sale to the general public. The shortage of staff and the distances involved in travelling, especially when only a single carcase is involved, mean that the majority of these animals are slaughtered without inspection. The only protection afforded is the knowledge from disease testing that the herds are tuberculosis and brucellosis free. The position is rapidly becoming more difficult with the proposed establishment of further small private slaughterhouses in other parts of the district. This dispersion of small inadequate slaughterhouses accentuates the need for a central meat processing works.

During 1959–60, 230 head of cattle were slaughtered.

New Britain District.

Killing for local consumption in the town of Rabaul has decreased considerably, only 23 cattle being slaughtered during the year. A number of plantations slaughter regularly for supply to their own labour lines. Pigs are slaughtered mainly for the Chinese population of the town. 1,919 carcases were inspected. Condemnation of legs of pigs has commonly been caused by the Native method of carrying the animals, leading to the development of indolent ulcers on the medial surfaces of the legs, from bruising from the carrying poles.

Highlands Districts.

One property regularly supplies carcases for the town of Goroka. 70 cattle were killed during the year.

Native labour employed by the Administration at Mount Hagen and on the station are supplied with fresh meat from the Western Highlands Livestock Station, Baiyer River. 83 animals were slaughtered for this purpose.

Madang District.

Occasional animals are slaughtered for supply to Madang. The Stock Inspector, Madang, is responsible for the inspection of carcases.

CLINICAL SERVICES.

Clinics are operated free of charge by Veterinary Officers in their respective districts. The following is a table of consultations:—

TABLE 4.—VETERINARY CONSULTATIONS, 1959–60.

District.	Number of Cases.
Central (Kila Laboratory)	602
Morobe	228
Highlands	170
New Britain	116

QUARANTINE SERVICES.

The Division maintains supervision over the importation of all animals and animal products into the Territory. The Territory has fewer serious animal diseases than Australia and this situation is maintained by strict quarantine.

Quarantine has become more important since the introduction of regular aircraft flights from Asian countries where serious exotic animal diseases are prevalent.

Importation of Animals.

Cattle.

During the year 155 head of cattle were imported. This included 60 head which were imported under the Administration subsidy scheme and 89 head imported for the Administration. Cattle imports were low when compared with previous years, mainly because of shipping difficulties.

Horses.

23 horses were imported including two stallions imported for use on Administration stations to improve the type of stock horse.

Pigs.

51 pigs were imported during the year—12 boars and 39 sows. Of these, 19 were privately owned, the remainder being imported for use on Administration stations.

Poultry.

77,000 day-old chickens were imported into the Territory of Papua and New Guinea during 1959–60. Another 6,425 were transhipped to Netherlands New Guinea and 650 to the British Solomon Islands Protectorate. 590 day-old ducklings and 338 day-old turkey poults were also imported.

Small Animals.

42 dogs, 4 cats, 96 canaries and finches and 36 pigeons were imported during the year.

All the above animals were imported from Australia.

Export of Animals.

Six weaner calves were exported from Aitape to Hollandia, Netherlands New Guinea. These animals were Mission owned. Four dogs were exported to the United Kingdom where they will remain in quarantine pending return to Australia.

VETERINARY RESEARCH.

Veterinary Laboratory.

The major part of the output of the laboratory during 1959–60 was concerned with diagnostic work for the field veterinary officers. Staff shortages have limited the initiation of research projects which are essential for the furtherance of knowledge of specific animal health problems in the Territory.

A preliminary investigation into the suitability of the red deer (*Cervus timorensis moluccensis*) as a host for the cattle tick (*Boophilus microplus*) was carried out. A larval survival rate of 0.4 per cent. was observed from one infestation of 100,000 larvae. Larval attachment was protected by a hessian coat. The deer reacted severely to the attachment of the larvae and blisters were produced over most of the back. These blisters soon burst and produced straw-coloured exudate. No observations were made as to whether viable eggs were produced by the engorged adult female ticks.

An earlier application of 20,000 ticks to two deer without the protection of hessian coats proved unsuccessful. No larval ticks were seen engorging and no adult ticks were collected from either test animal.

This study will be continued to give further information for application to eradication programmes in the Port Moresby area.

ANIMAL HUSBANDRY.

Extension of Animal Industries to Native Peoples.

Pigs.

Since the traditional animal in Native agriculture is the pig, the Department has embarked on a plan to improve the type of animal owned by the Native and to improve his husbandry methods so that pig production will become more efficient. Considerable education will be required to change the traditional attitude towards the pig. At present it is more or less a member of the man's family and an article indicating social prestige. This attitude must be modified until the pig is regarded as a source of food or income, as part of a mixed farming agricultural system.

Apart from traditional attitudes, there are two aspects of pig production which need attention, namely the improvement of pig husbandry and the provision of an adequate market for pig meats. One of the first approaches to improvement of husbandry for more efficient meat production is the introduction of improved breeds to produce a better type of animal with larger litters and greater efficiency of food conversion. To this end, piggeries have been established on Departmental livestock stations at Goroka, Baiyer River, Erap (near Lae) and Kurakakaul (near Rabaul). These piggeries are stocked with stud Berkshire animals imported from Australia and raised under intensive husbandry methods.

Of special significance is the improvement of pigs in the Highlands Districts where there is a chronic lack of animal protein in the diet of the Native people. The piggery at Goroka is playing an important part in providing pigs for distribution throughout the area and also for providing facilities for the service of Native-owned sows by stud Berkshire boars. This last method of pig improvement has been extended to three centres outside Goroka. Pens built to Departmental specifications have been constructed at Kundiawa, Kerowagi and Henganofi. The boars are under the control of the Agricultural Officer at each centre and the success of these three units will result in further extension of the project through the Highlands. There is a nominal charge for the service. The first cross with native pigs can produce a fine animal, as shown in Plate 1.

The pens are constructed of river stone and cement with a cement floor and half is roofed with grass thatch. They are built as a demonstration to the Natives of the type of pen which is needed for maintenance of pigs under adequate hygiene and husbandry.

The cost of such a construction is beyond the present resources of most Natives but is an ideal at which they should aim. A complete changeover to housing of all pigs would at present prove disastrous to the native economy. Not only is the capital cost of the housing high, but the food needs of the pigs would necessitate more than twice the present garden areas. A pig housed under an intensive system must be provided with all his food requirements in the daily ration. The pig is more demanding of food than the Native himself and this food would have to be produced from the garden areas. In addition some form of

PLATE 1—*The first cross between native sows and imported boars is a vigorous and productive animal.*
[Photograph Australian News and Information Bureau]

PLATE 2—*New Guineans are learning to apply the basic principles of animal husbandry in the Bena Native Cattle Project.*
[Photograph Division of Extension Services]

animal protein supplement would have to be purchased. The change to a more intensive and efficient method of husbandry must be gradual as the benefits of housing and feeding for economic meat production are learned.

Education towards the wider use of pigmeat in the present low protein Native diet should provide an immediate market for further production. Storage of the meat is a problem which needs consideration. The curing of ham and bacon is a distinct possibility under Highland conditions.

Cattle.

The largest concentration of cattle owned by Natives is in the Morobe District of New Guinea, where 216 cattle and 9 horses are under Native control. Of these the horses and 150 cattle are in the Wain Census Division where the Natives have been influenced by a local Mission. They have handled cattle since before the war and took over and tended some Mission-owned cattle during hostilities. Following the war, the Mission has supplied breeding stock and the number has steadily increased. All cattle are owned by individuals or family groups.

During 1959–60, the project was investigated by the Department and 20 heifers from the Western Highlands Livestock Station, Baiyer River, were made available for sale to the Natives of the area. The area concerned is at an altitude of over 3,000 feet and is thus suitable for British breeds of cattle. The animals have been tested for tuberculosis and brucellosis with negative results, and are free from cattle tick. They are grazed on natural grasses, being herded out during the day and returned to a fenced night paddock. There is some local overgrazing but there is adequate grassland available if better control is maintained.

Further projects concerned with Native ownership of cattle were commenced in the Eastern Highlands District. Three units have been established in the Bena Census Division involving the sale of twelve head of cattle to individuals of three separate villages. The husbandry is based upon the use of a securely-fenced night paddock with the animals being herded on common land during the day. In the first instance, the emphasis is on rearing calves and not upon the utilization of milk from cows. The breed sold to the Natives is a dual purpose type and the introduction of dairy techniques will follow successful raising. A typical herd is shown in Plate 2.

These first three projects are experimental and the extension of the scheme will depend on their success. The area of the Bena Census Division was selected because of the great potential for expansion into large areas of natural grassland. This grassland is traditional pig grazing land and since cattle are much better converters of grass to animal protein than are pigs, the country would become more productive when carrying cattle. The introduction of cattle would also provide an animal which is better suited to the establishment of a mixed farming agricultural system and which can utilize the large areas of land which are unsuitable for agriculture.

The success of these cattle projects will depend also on the provision of a market. In this respect development will be slow because of the time taken for slaughter animals to reach maturity. Because of the small number of animals involved, there should be little initial difficulty in disposal of killers but marketing will become increasingly important as the scheme expands.

LIVESTOCK STATIONS.

Nine livestock stations are operated by the Division throughout Papua and New Guinea. Two, the Animal Quarantine Station and Veterinary Laboratory, Kila Kila, Port Moresby, and the Animal Industry Centre, Three Mile, Lae, function as quarantine areas and bases from which Veterinary Officers and Stock Inspectors operate. The Papuan Lowlands Livestock Station, Moitaka, the Papuan Highlands Livestock Station, Bisianumu, the New Guinea Lowlands Livestock Station, Erap, and the Western Highlands Livestock Station, Baiyer River, maintain herds of Administration livestock for experiment and for distribution.

The Animal Industry Centre, Goroka, maintains a dairy herd and large stud piggery project. The whole of the main station was resumed during the year for town expansion leaving only 80 acres in the piggery area. The Animal Industry Centre, Kurakakaul, Rabaul, functions as a quarantine area and Veterinary Centre as well as maintaining a dairy herd and piggery project. The area of this station was reduced from 1,800 acres to approximately 320 acres. Development is now centred on this 320 acres.

The Upper Ramu Livestock Station, Arona, was released during the year and tenders were called for the purchase of the improvements on the station.

At the 30th June, 1960, these stations carried 2,798 cattle, 323 horses and 226 pigs. Table 5 shows the livestock statistics of all Animal Industry Stations for the year under review.

TABLE 5.—LIVESTOCK STATISTICS.

Station.	Cattle.						Horses.						Pigs.					
	Total. 1st July, 1959.	Natural Increase and Transfers.	Deaths.	Decrease Rations.	Decrease Sales and Transfers.	Total 30th June, 1960.	Total 1st July, 1959.	Natural Increase and Transfers.	Deaths.	Decrease Rations.	Decrease Sales and Transfers.	Total 30th June, 1960.	Total 1st July, 1959.	Natural Increase and Transfers.	Deaths.	Decrease Rations.	Decrease Sales and Transfers.	Total 30th June, 1960.
Moitaka ..	863	217	* 138	..	164	778	55	24	9	..	7	63	..	..	..	..	..	..
Bisianumu ..	190	108	33	..	7	258	15	..	3	..	3	9	..	..	..	..	..	..
Erap	639	218	† 73	25	255	504	51	9	1	..	..	59	21	85	4	3	71	28
Arona	66	14	7	1	18	54	105	22	24	..	38	65	5	11	1	1	9	5
Goroka ..	83	56	1	8	96	34	8	4	1	1	9	1	54	181	7	18	61	149
Baiyer River ..	904	308	54	88	60	1,010	89	36	12	..	1	112	0	7	..	..	..	7
Kurakakaul ..	251	68	3	8	148	160	14	1	1	..	..	14	0	44	7	..	..	37
Total ..	2,996	989	309	130	748	2,798	337	96	51	1	58	323	80	328	19	22	141	226

* Includes 70 calves which died in severe dry season.
† Includes 57 Brucellosis reactors slaughtered.

Three major projects are under way on Divisional Stations, as follows:

Zebu Cross-Breeding Project.

This is carried out in two parts—

(i) Brahman cross-breeding on the Papuan Lowlands Livestock Station, Moitaka, where Aberdeen-Angus is the major European breed used. Poll-Shorthorns are also used in a small scale project of grading up towards Brahman bulls.

(ii) Africander cross-breeding on the New Guinea Lowlands Livestock Station, Erap, where Poll-Shorthorns are the European breed used. Selection within the Shorthorn herd towards a more adapted type is also being carried out.

These two projects are aimed at developing a type of cattle which is adapted to the tropical environment of the Territory. Preliminary observations show that Brahman cross-bred cattle show a considerable improvement in performance over their European-breed counterparts in the hot lowland environment. The first distribution of Brahman crossbred bulls from the programme was made during 1959–60.

The Africander cross-breeding programme has begun only recently and no results are available.

Dairy Cattle Improvement Project.

Dairy cattle are maintained on three of the stations. At the Papuan Lowlands Livestock Station, Moitaka, and the Animal Industry Centre, Kurakakaul, Jersey cattle are used and at the Animal Industry Centre, Goroka, Australian Illawarra Shorthorn cattle are used. It has been found that Jersey cattle are better adapted to the hot lowland environment than are A.I.S. The reduction in size of the Animal Industry Centre, Goroka, has resulted in the transfer of a large number of animals to the Hallstrom Livestock and Fauna Trust Station, Nondugl.

It is intended that Sahiwal and Sindhi cattle owned by the Administration but held by C.S.I.R.O. in Australia should be introduced into the Jersey herds in the lowlands.

Pig Breeding Project.

Stud Berkshire pigs are maintained in piggeries at the Animal Industry Centre, Goroka, the New Guinea Lowlands Livestock Station, Erap, the Animal Industry Centre, Kurakakaul, and the Western Highlands Livestock Station, Baiyer River. On the first three stations facilities are being installed so that measurements of weight gain can be made and so that performance of pigs on various locally-produced rations can be determined. Breeding can then be based on selection towards increased performance under the prevailing conditions.

The majority of animals bred on these stations are available for distribution and many of them are sold to Native peoples. These piggeries play an important role in the policy of improving native pigs and pig husbandry.

A project of breeding Poll-Shorthorn cattle for distribution is carried out on the Western Highlands Livestock Station, Baiyer River. Selection within this herd is being directed towards conformation, weight gain and coat type.

A short description of the nine stations and their activities is set out below:

PAPUAN LOWLANDS LIVESTOCK STATION, MOITAKA.

This station is situated approximately eight miles from Port Moresby and is the largest under the control of the Division. Its area is approximately 40,000 acres of which just over 10,000 acres is fenced. The station is representative of the hot coastal environment of the Port Moresby area although atypical for the hot humid tropics. The rainfall is between 35 and 40 inches annually, almost all of which falls during the period November to March. There is a long dry period of up to nine months.

Livestock.

Cattle (Dairy).

A herd of approximately 90 head of Jersey cattle is maintained for milk production. These animals are being sampled for production and the figures are used in the selection of types which are high producing in this environment. The Jersey breed seems well adapted to the environment but milk production is disappointing.

A husbandry system based on the housing of calves from birth until 24 weeks will be introduced on the completion of the calf-pen under construction. This system should give calves an excellent start. Special weaner paddocks of guinea grass have been planted for use in conjunction with the calf pen.

Cattle (Beef).

As mentioned above, there is a cross-breeding project to develop a type of cattle adapted to the environment. The breeds of cattle in this project are the European breeds Aberdeen-Angus and Poll-Shorthorn and the Zebu breed, Brahman. The major breeding programme is based upon the Brahman/Aberdeen-Angus cross, while the small number of Poll-Shorthorn breeders have been used as a basis from which to develop a line of grade Brahman animals by continual back crossing to Brahman bulls.

In the first few years of the main project, the aim will be to produce a herd of animals with varying percentages of Brahman blood, which can be compared under existing environmental conditions. Future policy in determining the final aim of the project will be based upon observations made upon the performance of animals within the various percentage groups.

Preliminary observations on the limited number of animals produced have shown the obvious advantage of the infusion of Brahman blood into the European breeds available. The real advantage is shown at weaning when the crossbred suffers no setback whereas the pure Eurpoean breed makes practically no progress for up to 12 months following weaning.

During the year the first sales of crossbreds were held. The response to the offering showed the interest in this type of animal and prices of up to £200 were paid for 10 month old bulls. 181 animals were included in the sale.

Horses.

A second thoroughbred stallion was imported to the station during 1959–60. The breeding of stock horses is an important part of the station's functions. The presence of wild horses outside the station boundaries has caused difficulties in eradication of cattle tick. A number of these animals has been trapped. They are the progeny of pre-war Arab-type horses.

Goats.

A herd of grade Saanen goats is maintained on the station for native rations and for sale and distribution.

Capital Improvements.

The stockyards built in 1958–59 have been maintained and improved and are in excellent condition. A weighbridge was installed during 1959–60.

Pasture Improvement and Fodder Conservation.

An area of over 150 acres of Elephant grass (*Pennisetum purpureum*) is now well established on the Durand Strip section of the station and further areas are prepared for planting in the next wet season. This area is also planted to the vine legumes *Centrosema*, *Pueraria*, *Calopogonium* and *Clitoria*, which provide an excellent mixed pasture with the Elephant grass.

Para grass (*Brachiaria mutica*) has been planted out near the swamps in the same area and has progressed very well. Molasses grass (*Melinis minutiflora*) has been used following the primary burn on newly cleared ground. Results have been variable but there is a fair proportion of molasses grass through the area treated.

Eight acres of Guinea grass (*Panicum maximum*) and 3 acres of Buffel grass (*Cenchrus ciliaris*) were planted in the dairy area. Success will depend on the use of spray irrigation to supplement rainfall during the severe dry season. A further area of 30 acres is prepared for planting.

During the bad dry season for the first half of the year under review, all the silage on the station was fed out to the stock. This amounted to about 800 tons. This year an estimated 1,000 tons of Elephant grass was ensiled.

PAPUAN HIGHLANDS LIVESTOCK STATION, BISIANUMU.

This station is situated approximately 30 miles from Port Moresby at about 1,500 feet above sea level. The annual rainfall is approximately 100 inches with a dry season of about four months from May to August inclusive. The area of the station is 2,500 acres of which 300 acres is under the control of the Division of Plant Industry for rubber experimentation. Two types of country are represented:

(*a*) Rain forest which has a high carrying capacity and can be subjected to intensive pasture improvement.

(*b*) Savannah eucalypt forest which is covered mainly with Kangaroo grass and kunai and has a low carrying capacity.

Livestock.

The livestock on the station at 30th June, 1960, are shown in Table 5.

Cattle (*Brahman*).

The station maintains a stud of pure-bred Braham cattle, the original six animals having been imported from the United States of America in 1954. This stud is the basis from which sires are obtained for the cross-breeding programme on the Papuan Lowlands Livestock Station, Moitaka. Only two bull calves were born from the total of ten calves up to the 1959–60 calving. In 1959–60, however, four bulls and one heifer were born. As a result of the paucity of bull calves the cross-breeding programme on Moitaka is being retarded. Typical animals are shown in Plate 3.

An interesting observation on behaviour of these animals was recorded during the year. The cows with calves were mated when the calves were at an average of three months. Three months later none of the cows with calves at foot was pregnant although two of the younger heifers were. The calves were weaned to determine whether lactation was suppressing normal oestral cycles. Within seven days of weaning, all cows had been served and are now pregnant. It would appear from this limited observation that lactation has influenced oestrus in these animals.

Aberdeen-Angus.

This breed is maintained for distribution and for the breeding of replacements for the Papuan Lowlands Livestock Station, Moitaka. During 1959–60, 83 Aberdeen-Angus heifers were imported and have now been mated. These heifers were selected by officers of the C.S.I.R.O. on the basis of coat characteristics.

Red-Poll.

This dual purpose breed is maintained for distribution.

Horses.

A small number of horses is held. An imported thoroughbred stallion was stationed at Bisianumu during the year to recover from injuries received during the journey from Australia.

Pasture Improvement.

The area of cleared rain forest country has been planted down to Guinea grass in rows about 8 feet apart. These paddocks were closed up until the newly planted material seeded. The strike was excellent and the paddocks have now been used in rotation for the top line of Aberdeen-Angus cows. A multiplication plot was also sown to provide planting material in the coming wet season.

Animal Quarantine Station, Kila Kila.

This station, approximately 3 miles from Port Moresby, has an area of 65 acres and is enclosed by a 7-ft. barbed wire fence. Within the boundary are two double-fenced quarantine paddocks. The original improvements were constructed for the reception of cattle from Pakistan which were held in quarantine *en route* to Australia.

On the station is the Central Veterinary Laboratory which is referred to above.

Livestock.

The station maintains only a small number of animals for experimental purposes, including 7 cattle, 3 horses, 5 sheep and several goats. Guinea pigs are bred at the laboratory for experimental purposes. Their numbers are maintained at an average of 150. During the year a colony of mice was established and has been maintained. Two deer are held for experimental work on cattle tick life cycles.

Capital Improvements.

A new set of stockyards was completed within the main quarantine paddock.

A vermin-proof mouse house was constructed and also an infected animal house of the same design. A start was made on the construction of the incinerator.

Pasture Improvement.

Guinea grass and Buffel grass have been established with difficulty on what was an old airstrip. These grasses enable the station to maintain the experimental animals.

Animal Industry Centre, Three Mile, Lae.

The station is 300 acres of rain forest country astride the Markham Road, 3 miles from the town of Lae. 205 acres are cleared and fenced into seventeen paddocks. The rainfall on the station averages 150 inches a year and there is no pronounced dry season. A considerable area on the lower side of the road is swampy and needs draining before it can be used productively.

Livestock.

The station acts as a quarantine station and holding camp for stock imported through the port of Lae or moved through the town. It is the first line of defence for the detection of diseases in imported stock. It does not normally carry any livestock with the exception of two horses to assist in control of imported stock.

Capital Improvements.

A veterinary field laboratory was constructed, consisting of an office storeroom, laboratory and surgery. Pig pens were constructed for the maintenance of pigs on transfer from the New Guinea Lowlands Livestock Station, Erap. The pens are concrete-floored with subdivisions of steel marsden matting. This unit will also be used for pig auctions in the coming year. The stockyards and handling facilities, including a mechanical spray race, are constructed near the road so that imported animals can be treated when necessary.

Pasture Improvement.

Following clearing, the rain forest was replaced with Para grass and Guinea grass. Under the conditions on the station the Para grass is extremely vigorous and an almost complete cover has been obtained.

New Guinea Lowlands Livestock Station, Erap.

This station is situated in the Markham Valley 36 miles from Lae and has an area of 4,340 acres of mixed grazing and agricultural land. Most of the property is fenced and intensively sub-divided into 28 paddocks to permit a rotational grazing system. The heavy sub-division has created problems in providing water in all paddocks. The area is almost devoid of natural shade and the construction of shelters or planting of trees are essential The average rainfall is about 50 inches per year and falls in two distinct wet seasons.

Livestock.

The livestock present on the station at 30th June, 1960, are shown in Table 5.

Cattle.

A herd of beef Shorthorn cattle is maintained on the station. The environment is relatively unsuited to the maintenance of pure British breeds. Imported bulls particularly do not adapt themselves to the conditions and calving percentages have consequently been disappointing in the past.

The first mating in the Africander cross-breeding project was undertaken this year following the coat scoring of all the breeders on the station by Mr. H. G. Turner of C.S.I.R.O. This is the basis of a breeding programme designed to produce an animal adapted to the environment of the Markham Valley. Pure Shorthorns are also being selected for coat type and performance in an attempt to produce a British-breed animal which can thrive under the local conditions.

The spraying programme for eradication of cattle tick was completed in June, 1960. The property will be maintained under inspection for a further twelve months.

Two successful auction sales were held during the year. In August, 1959, 98 head were sold and in May, 1960, a further 90 head were sold. The revenue from these sales was £4,098.

Pigs.

During the year stud Berkshire pigs were introduced onto the station to replace the previous grade herd. The majority of the progeny are distributed through the Division of Extension and Marketing to Natives of the Morobe District. The breeding herd included eighteen sows and three boars. Seventy-one piglets were sold off the station during the year.

All pigs are maintained under an intensive husbandry system entirely on concrete. Facilities are being installed to measure performance. From the stud pigs, nine litters have been born, with an average litter size of 7.4 piglets.

PLATE 3—*Brahman cows and calves in the cattle yards at Bisianumu.*
[Photograph Australian News and Information Bureau]

PLATE 4—*Indigenous farmers are taught branding and other operations at Administration Livestock Stations.*
[Photograph Australian News and Information Bureau]

Horses.

Horses are maintained for stock work. The stallion "High Adventure" which is destined for the Western Highlands Livestock Station, Baiyer River, was held on the station for two months. A stallion has now been purchased for retention.

Donkeys.

Donkeys are used by the Natives of the Upper Erap Valley to carry produce down to the Markham Road. They are regularly returned to the station and rested animals sent out to replace them.

Piggery.

A new piggery was constructed with all concrete floors and marsden matting sub-divisions. This is incomplete and construction will be continued into the new year.

Stockyards.

A new set of stockyards has been planned and was commenced during 1958–59. It is still incomplete. A weighbridge has been included in the yards for measurement of performance.

Bull Paddock.

A securely fenced bull paddock with 5 ft. 6 in. fences has been constructed to hold the bulls over the major portion of the year. Two separate pens are available for the Africander bulls.

Pasture Improvement.

A start has been made in establishing areas of improved pastures. Trials are also under way, supervised by the Agronomist from Bubia. The chief grasses used are Guinea grass, Elephant grass, Buffel grass and Para grass. The last has been planted in the low-lying swampy areas and Buffel grass has been tried on the stony ridges which, in their natural state, carry Kangaroo grass.

Cultivation.

Grain supplies of sorghum and maize for the pigs are grown on the station.

Watering Facilities.

As mentioned above, the intensive sub-division of the station poses problems of supply of water to the many paddocks. Natural supplies available in some parts are soon polluted by the trampling of the stock. Wells have been sunk in various places. Good water with adequate flow has been obtained on the parts nearest the Markham River. A well near the piggery gives an inadequate flow at 54 feet, and is being deepened. A survey of the station has been carried out for the possible sinking of bores for permanent water supplies.

Animal Industry Centre, Goroka.

This station is divided into two parts. One area of 284 acres was resumed into the town plan during the year, although some of it is still being used. The second area of 85 acres about 4 miles from the town is established as a stud piggery.

The elevation of the station is 5,500 feet and the rainfall is 80 inches annually. There is a pronounced dry season.

Livestock.

The livestock on the station at 30th June, 1960, are shown in Table 5.

Cattle.

A herd of grade Australian Illawarra Shorthorn dairy stock was maintained. Because of the resumption of the main station, it was considerably reduced by transfer and sale. Fifty-one animals were sold mostly at auction and 23 transferred to the Hallstrom Livestock and Fauna Trust Station, Nondugl.

With the concentration of the remainder of the cattle on the piggery area, a new husbandry system will be introduced and records of milk production maintained.

Pigs.

The imported stud Berkshire pigs are maintained under an intensive husbandry system. The piggery has been constructed with concrete floors throughout. The original pens were divided by marsden matting fences which proved most successful but the new pens have been built in river stone and cement. This type of construction seems well suited to the local

conditions and is relatively cheap because of the availability of the basic building materials. Facilities have been constructed for the measurement of performance of the animals. Round farrowing pens of galvanized piping have also been built.

The stud piggery project is under the general supervision of the Veterinary Officer, Goroka, and is the major part of the plan to improve the native pigs and pig husbandry.

Ration scales have been formulated using local foodstuffs as far as possible. Litter sizes have been disappointing, which may have been partly due to the age of the sows at the first mating. They had been held in quarantine before delivery to Goroka. The litter size has increased during the year; to date 42 sows have farrowed an average of five piglets per litter.

Fifty-four pigs were sold during the year and seven transferred to the Western Highlands Livestock Station, Baiyer River.

Capital Improvements.

The piggery has been almost completed. The transfer of sheds and equipment from the main station will mean further building development in the coming year.

A boar pen of river stone and cement construction was erected near the main gate of the piggery area. This houses a boar for the service of native-owned sows.

Pasture Improvement.

Elephant grass and Guinea grass are the two most successful species and 22 acres have been planted. Para grass is planted in wetter areas.

Water Supply.

A hydraulic ram has been purchased for the station and will be installed on an adjacent creek.

Western Highlands Livestock Station, Baiyer River.

This station with an area of 15,000 acres at an elevation of 3,500 feet includes most of the valley of the Baiyer River. The average rainfall over the last five years is just over 100 inches annually. 1959-60 with a recording of 112.95 inches was the wettest year on record. The drier season extends from May to August, but rain is well distributed throughout the year. Ten thousand acres of country on the left bank of the Baiyer River is securely fenced and sub-divided into 28 paddocks. The remainder of the station on the right bank of the Baiyer River is unimproved.

Livestock.

The livestock on the station at the 30th June, 1960, are shown in Table 5.

Cattle.

A herd of beef Shorthorn animals is maintained. Calving percentages have improved on the performances of previous years. 440 breeders were joined with 4 per cent bulls in September, 1958. 309 calves were branded from this joining and 39 deaths in calves from birth to branding were recorded. This is a 79 per cent calving and a 70.2 per cent marking. Calving commenced again on June 1st, 1960, with 85 calves to June 30th.

Culling has been carried out for the first time. 70 breeders were culled for inability to rear calves and general unthriftiness and 20 heifers for poor growth and poor coat characteristics.

83 head have been killed for rations and for supply to Mount Hagen. During the year an experimental air-lift of beef was carried out from Baiyer River to Port Moresby. The airlift proved that unchilled beef could be carried over long distances in the Territory without deterioration.

Plate 4 shows Native employees learning such operations as branding.

Horses.

Horses are bred for stock work. The thoroughbred stallion " High Adventure " is being held on the New Guinea Lowlands Livestock Station, Erap, pending arrangements for his transfer by road to Baiyer River.

Sheep.

A small flock of sheep is maintained for Native labour rations.

Pigs.

Six sows and a boar were transferred from the Animal Industry Centre, Goroka, to utilise offal from station slaughterings. They have not yet been mated.

Capital Improvements.

A seven sty piggery was constructed during the year and a new concrete-floored dairy was commenced. The homestead stockyards have been maintained and small sets built in association with each stockman's outstation.

Watering Facilities.

A windmill supplying two 5,000 gallon tanks on steel tank stands supplies the Manager's residence, the yards, piggery, stable, dairy, Native labour quarters and other station buildings.

Pasture Improvement.

Guinea grass, Elephant grass and Para grass have been planted on 200 acres. *Centrosema* was planted in conjunction with the grasses but growth was disappointing. Calves weaned on stands of improved pasture have shown markedly better condition than calves weaned on natural pastures in previous years.

Molasses grass was broadcast in areas where cultivation for the planting of other species is impossible.

Animal Industry Centre, Kurakakaul.

This station of approximately 1,800 acres is seven miles from Rabaul on the north coast of the Gazelle Peninsula. 320 acres of the sea front of the station have been delineated and fenced as the Departmental requirement. Most of the area is rather hilly and was originally a coconut plantation. The rainfall is about 70 inches annually with a pronounced dry season from May to August.

Livestock.

The livestock statistics of the station are shown in Table 5.

Cattle.

A grade Jersey herd is maintained on the station. Until 1959–60, no new blood had been introduced since its establishment in 1949. The present aim is to retain the Jersey herd as a model dairy, selecting for production, the milk being used for the piggery established on the station. Cross-bred cattle (Jersey, A.I.S., Aberdeen-Angus) still remain on the station but the majority have been sold. Facilities for the initiation of the dairy project are not yet complete.

At an auction sale in October, 146 head of cattle were sold. The majority were A.I.S., Aberdeen-Angus and crossbreds.

Pigs.

Stud Berkshire pigs were imported during the year. Five litters have been born to date giving a litter average of 7.4 piglets. Ration scales have been prepared utilising local foodstuffs as far as possible.

Horses.

A thoroughbred stallion " Prince Gaekwar " was imported during the year to recommence the breeding of horses.

Capital Improvements.

The piggery, with a concrete floor and marsden matting subdivisions, was constructed under a grass thatch roof supported on a welded pipe framework. A second piggery of similar design has been commenced to house native-type pigs which will be used in experiments to compare performance of these pigs and crossbreds with Berkshires.

The foundations of the dairy have been completed and the associated yards and feeding bails have been pegged out. Construction will be completed early in the New Year.

Fencing.

Bulls are housed in individual pens which are provided with shelters, service yards and watering points. The whole of the 320 acres required is boundary fenced and sub-divided.

Pasture Improvement.

Approximately 80 acres of Guinea grass and *Centrosema* comprise the bulk of the improved pasture on the station. Five acres of Elephant grass is planted and in the year under review, 15 acres was sown to a Buffel grass and *Centrosema* mixture; the strike was patchy but the seeding habits of the grass should improve the stand.

Fodder Conservation

Approximately 20 acres of sorghum was sown for silage. This material was harvested and ensiled in a trench. Some Guinea grass, Elephant grass and legumes were added to the silage. All material was chaffed before ensiling.

Watering Facilities.

Water is provided from wells on the sea front. The water is pumped to tanks on high points of the station and reticulated by gravity to most parts of the station.

The following Tables show the current cattle population in the Territory of Papua and New Guinea and the sales of Administration livestock during the past year:—

TABLE 6.—CATTLE POPULATION, TERRITORY OF PAPUA AND NEW GUINEA FOR THE YEAR ENDING 30TH JUNE, 1960.

Papua—		
Central District	3,666	
Milne Bay District	550	
Northern District	520	
Gulf District	127	
Western District	67	
Southern Highlands District	54	
	4,984	
New Guinea—		
Morobe District	5,000	
Madang District	2,168	
Eastern Highlands District	1,220	
Western Highlands District	1,855	
Sepik District	340	
Manus District	159	
New Britain District	1,184	
New Ireland District	409	
Bougainville District	159	
	12,494	
Total		17,478

TABLE 7.—SALES OF LIVESTOCK FROM ADMINISTRATION STATIONS, YEAR ENDING 30TH JUNE, 1960.

Category.	Stores.	Breeders.	Total.	Revenue.
				£ s. d.
Cattle	482	162	644	13,348 15 0
Pigs	..	121	121	1,294 10 0
Horses	..	..	11	424 0 0

DIVISION OF PLANT INDUSTRY.

LOWLANDS AGRICULTURAL EXPERIMENT STATION, KERAVAT.

The L.A.E.S., Keravat, is the major low altitude Experiment Station in Papua-New Guinea. It is situated about 25 miles from Rabaul on the Gazelle Peninsula of New Britain, on the pumice soils typical of the area. The altitude ranges from near sea level to several hundred feet above sea level. The annual rainfall is about 110 inches, with seasonal distribution, although the dry season is not severe. The total area is about 5,000 acres, mainly hilly to rough and broken country, but about 10 per cent. is flat or nearly flat. The station may be said to represent typical good Gazelle Peninsula plantation conditions in what is the most intensively developed area of Papua-New Guinea. A plan of the station is given in Figure 9.

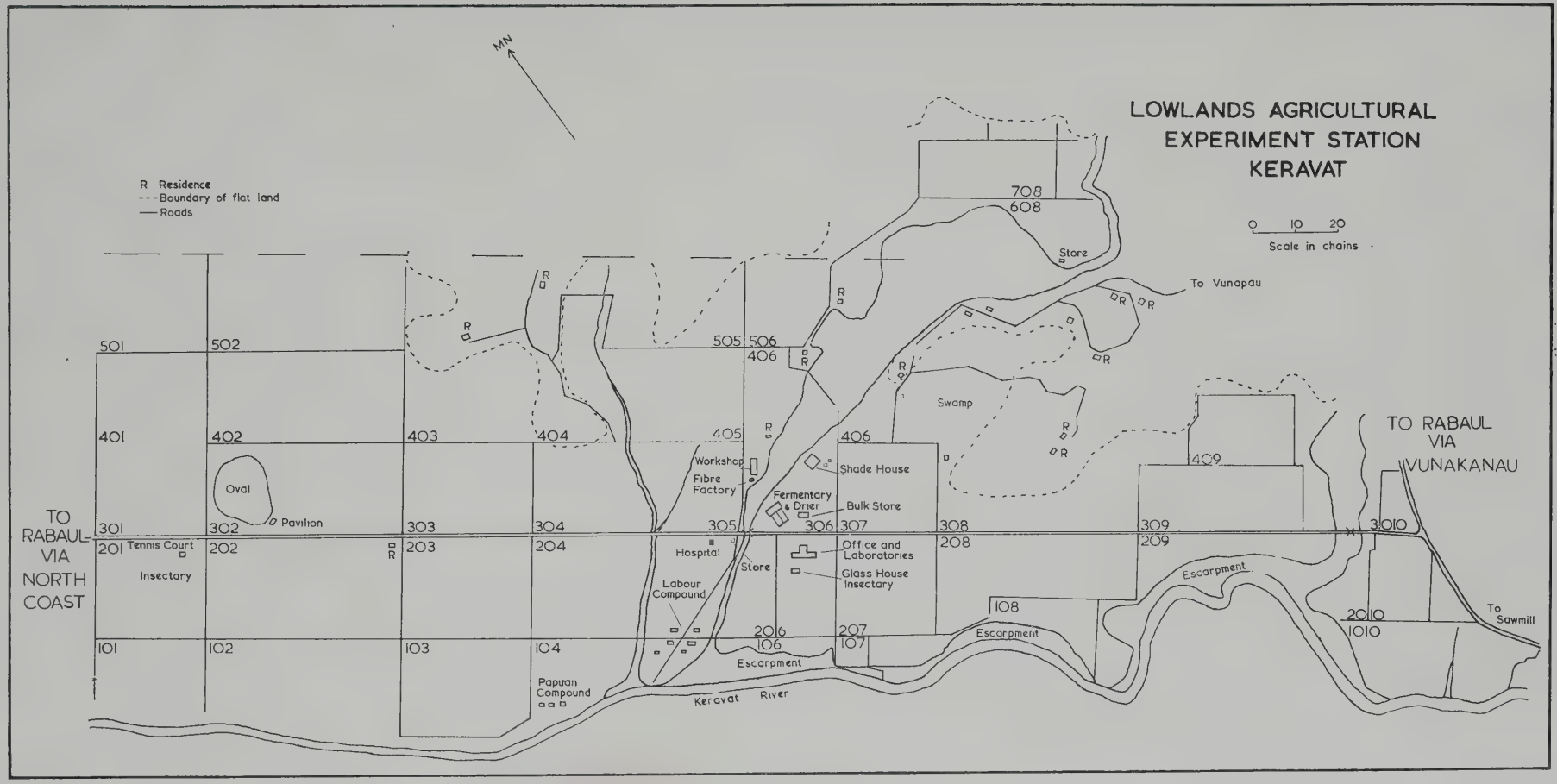

FIGURE 9—*Plan of the Lowlands Agricultural Experiment Station, Keravat.*

Keravat is the major centre for investigations on cacao, coconuts, manila hemp and robusta coffee. Major crop rotation and soil exhaustion trials and experiments with native food crops are also conducted, with the aim of rationalizing subsistence agricultural patterns. The station has extensive modern laboratories where agricultural chemists, entomologists and pathologists work. Their investigations are reported under their respective specialist sections. The agronomic work of the station will be discussed on a crop basis.

Cacao.

The cacao material in Papua-New Guinea falls within the Trinitario complex. It probably came from stock introduced from Trinidad by way of Java, Ceylon and Samoa. There is also some evidence to suggest a direct introduction from Venezuela at one stage. These introductions began at about the turn of the century and continued until 1907. The only subsequent introduction was from Java in 1932. The New Guinea Department of Agriculture assembled planting material from certain known sources at Keravat about 1930. No systematic selection was carried out and different types became thoroughly inter-crossed. The original parent trees in the Rabaul Botanic Gardens were destroyed during the war and the plantings at Keravat were decimated. Material selected and re-assembled at Keravat from remnants of surviving cacao is in sum total of a Trinitario type.

The first break in the policy not to introduce other planting material was made in 1959 when negotiations commenced to bring in Upper Amazonian clones. This material will be in intermediate quarantine for some time and only seed of known parentage will enter the Territory, as a protection against the introduction from the New World of many serious pests and diseases from which the Territory at present is fortunately free.

Intensive selection and hybridisation have been carried out at Keravat in the post-war years (*See* " Cacao Improvement Programme, Keravat "—L. A. Bridgland. *Papua and New Guinea agric. J.* **12**, (4): 149–167 (1960).) The basic breeding aim is to produce early high yielding types without weakening other desirable characteristics such as high fat content, flavour, vigour and disease and pest resistance. In translating this objective into a programme, three separate avenues of investigation have been followed concurrently, namely the development of clonal seed, the development of clones for direct commercial use and the development of hybrid seed. Major work on processing to make the most of inherent chocolate flavour has also been carried out. The main work on cacao can be sub-divided into cacao breeding and cacao agronomy.

Cacao Breeding.

Open-pollinated progeny trials—Blocks 304, 305, 405 *and* 406.

These were the first post-war trials laid down at Keravat, using pods taken from selected mother trees growing on Keravat and commercial plantations, in order to salvage as much as possible of the genetic potential of material which had survived the war. All systematic records of pre-war work had been lost. The mother trees initially selected covered a wide range from Amelonado and Calabacillo types to pure Criollo. These trees were selected on the basis of vigour, disease and pest resistance, apparent yielding ability and pod and bean characters. The open-pollinated progeny trials have been of great value in providing information on general combining ability as well as supplying a useful cacao population for selection purposes. Individual tree records maintained for almost 10 years have formed the basis of selection of the major clones which form the foundation of all more detailed work.

Progeny Testing—Blocks 106, 107, 108 *and* 3010.

Seedlings resulting from hand-pollination, whether crossed or selfed, have been progressively planted out in these blocks over the last six years. The primary purposes of this progeny testing programme have been to test the effects of inbreeding and, if possible, supply inbreds which will be useful parents for hybrid seed production, and to derive, from crosses between outstanding mother trees, seedling families from which superior clones might be selected, both as parents and for direct use.

Many of these progenies have been in bearing for several years. Selfed progenies are uniformly less vigorous than crossed progenies. As well as loss of vigour, inbreeding has been shown to lead to lower viability, deformities in leaf form and other abnormalities in many instances. The undesirable effects of inbreeding lend support to the theory that sufficient heterosis might be obtained in an outbreeding programme to be exploited in the production of high yielding clones. One fact which has emerged in the selfed progenies in

Block 106 is that none of the 170 trees produced from self-pollinated parents is itself self-incompatible so that it will not be possible to use two inbred parents for large scale hybrid seed production. This is in accordance with overseas findings that the genetic factor for self-compatibility is recessive so that self-compatible clones will breed true for this characteristic.

Some individual trees produced from hand-crosses have sufficient merit to be selected for testing as clones and also as parents.

Clonal Seed Gardens—Blocks 209 *and* 308.

The term " clonal seed " is used to denote the progeny of the crossing of two clones. Although this usage is inexact, it has become the generally accepted term.

There are problems in the distribution of clones in a large territory such as Papua-New Guinea with scattered cacao growing areas with poor communications. There is thus a good case for attempting to develop superior clonal seed in addition to clones, particularly in view of the greater ease of establishment of seedlings and certain other advantages which they have over clones.

The open-pollinated progeny trials with selected mother trees have shown that the best progenies yielded at least 40 per cent. more than the average. Over a five year period, the progeny of K6 yielded 1,227 lb. of dry beans per acre and K23 1,189 lb. per acre compared with a mean for all progenies at 852 lb. per acre. It is reasonable to suppose that control of the male parent could lift yield further. At all events, the likelihood of a cross between two selected clones giving seed of poorer potential than bulk unselected seed is remote and there is a likelihood of substantial gain in at least some such crosses. Pairing a self-incompatible with a self-compatible parent in seed gardens and using the incompatible clone as a source of seed for planting may provide the quickest way of producing improved seed in commercial quantities. Insufficient is known regarding the possibility of cross-compatibility between self-incompatible clones in the population to consider using such crosses at present.

Some 65 clonal seed gardens have been planted at Keravat as cuttings of parent trees have become available. The isolation is not all that might be desired but it is probably sufficient to ensure that most seed harvested from later gardens at least will be the desired cross. In the first gardens established, there was a scarcity of self-compatible clones. Gardens took the form of a single line of a self-compatible clone with two surround lines of the self-incompatible parent. Two lines of Robusta coffee were planted between the seed gardens to form a rough barrier and seed was harvested only from the inner lines of the self-incompatible clones. As material from self-compatible clones became available in greater quantity, the gardens were designed with self-incompatible central lines with a triple compatible surround. Seed from these later gardens should be fully satisfactory.

The pairing of clones in these gardens has been highly empirical. Pairings between similar and divergent types were made. Where a clone appeared to be weak in a particular characteristic, it was paired with a clone strong in that regard.

Some of the clonal seed gardens are now in early bearing and progeny testing is proceeding. When the results of progeny testing come to hand, gardens yielding unimproved seed will be discarded and the remainder extended.

Clone Testing.

The simplest approach to cacao improvement is by the vegetative propagation of desirable clones. Its possibilities are limited only by the variability of the seedling population on which it is based. The only form of vegetative propagation considered has been the use of cuttings. Satisfactory methods for striking and field establishment of cuttings have been worked out at Keravat. There are problems associated with the use of rooted cuttings including cost, difficulty in transportation and weakness in the early stages of growth. Methods perfected overseas using plastic bags have been tried and if fully successful here will go a long way to solving the transport problem. However, even at its best, the young cutting is not so hardy as the young seedling and requires " nursing " in its early stages of growth. A well-grown tree propagated by cutting is shown in Plate 5.

Sixty clones are being tested, 20 of which are self-compatible and 40 self-incompatible. Clones are tested in series of thirteen in a modified randomized block design which eliminates the possibility that fertilization of self-incompatible clones might become a factor limiting yield. Nine self-incompatible clones are used in 3 x 2 plots with double self-compatible surrounds. There are four replicates and a different self-compatible clone is used as the pollen source in each replicate. This has been repeated five times and a single self-compatible clone forms a bridge between all series.

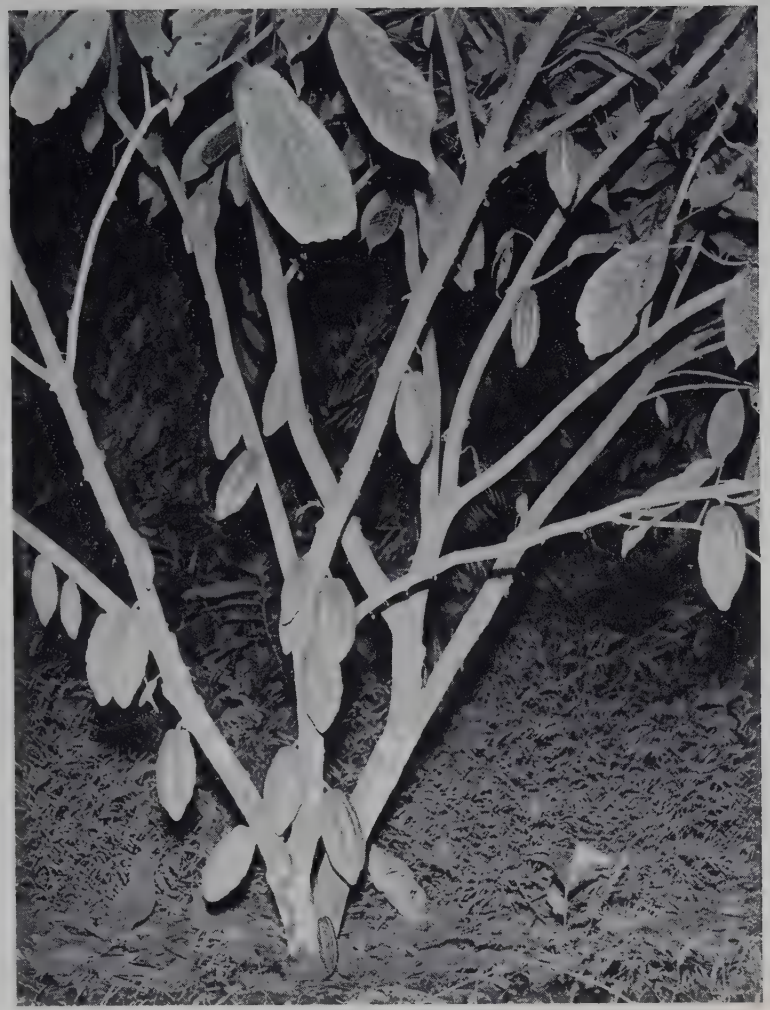

PLATE 5—*A well-grown cacao fan cutting at three years of age.*
[Photograph A. E. Charles]

PLATE 6—*Cacao cuttings are rooted under glass in propagating boxes.*
[Photograph Australian News and Information Bureau]

In addition to testing the yielding ability of the clones involved, these trials will provide information on the influence of male parentage on flavour and fat content by comparison of the same self-incompatible clones from each replicate. Furthermore, 36 different lines of clonal seed will be produced.

Self-compatible clones not included in the above trial are being tested in a separate randomized block which includes the same bridging clone.

Pod yields have been taken for two years for the first series and recording has commenced in the second series. The very early indications of yield are most promising and there is little doubt that some clones will prove acceptable commercially although some have an undesirable habit which will make them unacceptable even if high yielding. Net bag ferments of the individual clones in series I have been made and assessments of chocolate flavour and skin and fat percentage are being carried out.

Pollen Dispersal Trials.

Information about pollen dispersal is important both for planning research and commercial planting of clones. Although it is envisaged that commercial plantings, at least in the early stages, will be polyclonal rather than monoclonal, it would still be possible to limit potential yield of clonal plantings by lack of pollinators. Ceratopogonid midges of the genus *Forcipomyia* are responsible for pollination in Papua-New Guinea but little is known about the limits of pollen movement through their agency. Three trials have been laid down to elucidate this problem. They take the form of isolated blocks each of approximately 21 x 21 trees. In Trial A, the centre line of the block is planted with a self-compatible clone (KT82) with a uniform dark purple break and the surround lines are planted with a self-compatible clone (KT14) with a uniform pure white break. In Trial B, the centre line of the block is planted with KT14 and the surround lines are planted with KT82. In Trial C, the centre line of the block is planted with KT82 and the surround lines are planted with a self-incompatible clone (KT8) with a uniform pure white break.

The break of the pods set in the surrounds and setting and break in Trial C should make it possible to trace pollen movement with reasonable accuracy. It will be a simple matter to determine the pollen source by cutting beans and such observations will be made six months after the two clones in each block have been observed to be flowering in phase. The three trials are fully planted but it will be two to three years before results can be expected.

Hybrid Seed Development—Block 309.

Using inbreds from Block 106 as male parents and selected self-incompatible clones as female parents, hybrid seed has been produced by hand-pollination and progenies planted out in Block 309. It was originally planned that two inbreds should be used as parents but as already pointed out, such a procedure would be possible only when hand-pollination was resorted to because of the self-compatibility of all inbreds, and thus would have no commercial applicability.

The production of this so-called hybrid seed is essentially a refinement and extension of the production of clonal seed, one parent having been inbred for one generation. The parents used in the trial are grouped into two groups, namely near-Criollo and near-Forastero, and 24 like and 24 unlike crosses are compared. The trial will give information on specific combining ability in each of 48 crosses and also on the expression of heterosis, particularly with regard to the expectation that crosses between unlike parents should exhibit more heterosis than crosses between like parents. The design is a triple rectangular lattice involving twelve groups of three replicates, each group consisting of four crosses, two like and two unlike. Plot size is 4 x 4 trees. This trial is newly laid down and will not yield results for some years.

Concurrently with the testing of this hand-pollinated hybrid seed, hybrid seed gardens are being planted using the same clones in the same combinations, so that when results are forthcoming indicating that certain combinations are superior, seed will be available. The first seed garden (K23 x KT74) has been planted out and a start made with other gardens.

Cacao Agronomy.

Shade x Spacing Trial—Block 506.

This trial commenced seven years ago and the results have been most interesting. There are two spacings used, namely 12 feet and 15 feet, both on the triangle, and two shade treatments, namely " normal " shade and complete removal of shade after the closing of the cacao canopy. In the early years, there was a marked increase in yield at both spacings in the plots from which shade had been removed. In addition, the trees spaced at 12 feet with

or without shade consistently yielded more than trees spaced at 15 feet and in some years the difference was statistically significant. In the first five years, 12 feet spacing yielded 27 per cent. more than 15 feet spacing.

At both spacings, the initial period of greatly increased yield following shade removal was followed by a decline and in 1957–58 the yield of the unshaded blocks fell below that of the shaded. Since then the trend has again been reversed and although the unshaded trees look less healthy than the shaded, it is too early to predict the ultimate trends in this trial. The use of shade at all stages of the growth of cacao is at present a standard Departmental recommendation.

Shade Trial—Block 405.

The results from the shade and spacing trial in Block 506 suggest that if shade is necessary at all for maximum production in mature cacao, there is an optimum level which may be less, at least under Kerevat conditions, than has been generally recommended in the past. To test this supposition, an area of mature cacao was selected in Block 405 for a trial to test different levels of shade. The design is a randomized block of four shade treatments with four replications. The shade treatments are:

" Normal " shade—1 mature *Leucaena glauca* to 1 cacao tree.

$^1/_2$ " normal " shade—1 mature *Leucaena glauca* to 2 cacao trees.

$^1/_4$ " normal " shade—1 mature *Leucaena glauca* to 4 cacao trees.

No shade.

Shade was lifted gradually over a period of twelve months with the final shade thinning in February, 1959. Yield figures for the first twelve months indicated a negative correlation between yields and shade level. This is in line with experience in Block 506 and it will be some years before longer term trends are likely to emerge.

Seedling Spacing Trial—Block 2010.

This trial comprises an initial area planted at five triangular spacings (12 feet, 15 feet, 17 ft. 2 in., 20 feet and 24 feet) with four replications. The objectives of the trial are as follows:

To measure time/yield relationship at various spacings.

To compare cost of establishment and maintenance at various spacings.

To study the relationship between vigour and yield and the changing pattern of inter-tree competition as the stand comes to maturity.

This trial arose from the results obtained from the recordings of open-pollinated progenies in Block 304. Cacao seed was planted in October, 1956, the seed being carefully mixed to prevent individual progeny effects obscuring the results. The first vigour measurements have been made and yield records are being maintained. It will take several years for trends to emerge, particularly with regard to the third objective of the trial, namely the study of the relationship between vigour and yield. This has an important bearing on the basis of selection of mother trees in stands of cacao at normal spacings. Study of the results from open-pollinated progeny trials in Block 304 suggests that competition is important in determining the performance of mature trees and while selection at too early an age may differentiate only the precocious types, selection at too late an age may create a bias towards trees of high competitive ability rather than high genetic yielding ability. Such trees would not necessarily reproduce comparable yields when grown as clones under conditions of uniform competition.

After completion of the planting of this seedling spacing trial, attention became focused on the possibilities of hedge spacing rather than triangular spacing for commercial cacao and an adjoining area was planted with four replications of two hedge spacings, namely 18 ft. x 8 ft. and 24 ft. x 6 ft. Yield records only will be kept for these hedge spacings which were planted in August, 1957.

Spacing x Pruning Trial—Clonal Material.

The commercial use of clonal cuttings presents a number of problems which differ from those encountered with seedlings. When cuttings are planted on conventional triangular or square patterns, the branches of contiguous trees become intertwined close to the ground and it is difficult to move through the stand. These problems are accentuated in clones of lax habit. Pruning and/or hedge planting offer possibilities in overcoming this problem.

The objectives of the spacing x pruning trial are to determine time/yield relationships at various spacings and to determine the effect of pruning on these relationships and on resistance to damage by wind, pests and diseases. The design is a split plot using five spacings with two prunings and two replications. The spacings are 9 feet, 11 ft. 6 in. and 14 feet, all on the triangle, and hedge spacings 18 feet x 6 feet and 18 feet x 4 feet. Each spacing is split with half the plot left unpruned.

Trees have started to bear only in the last twelve months so that it is too soon to discuss yields. It has, however, already clearly emerged from the viewpoint of management that hedge plantings with pruning have many advantages. The Department is tentatively recommending that clones be planted at a hedge spacing of 18 feet x 6 feet which gives a tree density almost twice as great as that obtained with the conventional 15-ft. triangular spacing.

Vegetative Propagation.

An essential concomitant of the improvement programme has been the development of a satisfactory method of striking cuttings and establishing them in the field. Full reports of these investigations have been published in the *Papua and New Guinea Agricultural Journal.*

During the course of these investigations, the following variables were studied:

(i) Maturity of leaves at the time of collection.
(ii) Number of leaves per cutting.
(iii) Length of leaves of the cutting.
(iv) Nature and concentration of the root-inducing hormones.
(v) Type of propagator.
(vi) Type of medium (organic or inorganic).
(vii) Frequency and intensity of watering.

All experiments were statistically designed, usually using randomized blocks. Each propagating box held 32 cuttings and the smallest sub-plots used contained eight cuttings.

The method of propagation in common use at Keravat involves striking semi-hardwood cuttings in leached sawdust in wooden boxes covered with cloth-covered glass. (*See* Plate 6.) The cuttings root in 27 to 30 days, at the end of which time they are lifted and transplanted into a potting medium prepared from the mulch beneath stands of *Mimosa invisa.* Baskets are used and the basketed cuttings placed on a concrete floor under 50 per cent. incident sunlight and subjected to almost continuous watering with a very fine spray for four to six days. Watering is then reduced to one to three sprays per day, each of ten to twenty minutes' duration, for two and one-half to three weeks. After this the baskets are stood under shade of *Leucaena glauca* for six to eight weeks and receive no further watering beyond normal precipitation, unless a very dry spell occurs. The cuttings are then ready for transplating into the field. This method of propagation is satisfactory but the cost is approximately 2s. per cutting and transport for any distance is difficult and expensive. Further work will aim at reducing the cost per cutting while retaining the high percentage establishment already attained. Striking cuttings in polythene bags has shown promise but further work is needed under local conditions before the method can be recommended.

Since 1959 limited numbers of clonal cuttings have been distributed to planters as well as for clonal trials on agricultural stations.

Cacao Fermentation.

The aim of the experimental programme commenced some years ago at Keravat was to devise reliable methods of fermentation which would regularly ensure the production of high quality beans. The need for improved methods of fermentation was felt particularly in the Gazelle Peninsula of New Britain where " dead " ferments occur frequently enough to pose a problem to many growers. In a " dead " ferment, the fermenting mass fails to attain the usual temperatures and even when fermentation is prolonged, the beans do not develop the colour and flavour desired. " Dead " ferments usually end in putrefaction. It appears that problems of this nature occur more frequently in Papua-New Guinea than in most other cacao growing areas of the world.

In the course of the experimental programme, many variations of normal fermentation procedure were tried and innovations introduced. In many instances, whole boxes of beans were subjected to experimental treatment or, as may have been appropriate to specific investigations, small quantities of beans were placed in a net or plastic bag within a bulk ferment. The fermented beans were then examined at Keravat and also by Australian

chocolate manufacturers, who made up finished chocolate from them, and assessed the degree of fermentation, strength of chocolate flavour and presence or absence of objectionable flavours and odours.

For the maximum development of the chocolate flavour inherent in cocoa beans without introducing foreign flavours, the beans must be subjected to certain conditions of temperature and acidity for specific periods and then carefully dried. The drying process as well as the fermentation process may be critical and both were investigated. The work has been published in full in the following articles: " Cacao Processing—History and Principles "—L. A. Bridgland, *Papua and New Guinea agric. J.*, **12**, (2 & 3): 49–85, (1959), and " Processing Methods for Cacao Growers in Papua and New Guinea "—L. A. Bridgland, *Papua and New Guinea agric. J.*, **12**, (2 & 3): 87–115, (1959).

The main variations tried in fermentation were as follows:

(i) Addition of sugar at various stages.
(ii) Addition of water early in the fermentation process.
(iii) Addition of yeast cultures early in the ferment.
(iv) Forced ventilation of the fermenting mass.
(v) Induction of better aeration by such methods as the insertion of perforated bamboo tubes in the ferments.
(vi) Wiping the interior of fermentation boxes with fermented beans prior to introduction of a new charge to ensure adequate microbial inoculation.
(vii) Lining the sweat boxes inside or outside with polythene sheeting.
(viii) " Resting " the beans by spreading thinly on a covered floor soon after initiation of fermentation. " Resting " periods varied up to 40 hours.
(ix) Varying the period of viability of the beans.
(x) Varying the period between harvesting and breaking.

In the investigation of drying procedure, the following experimental procedures were studied:

(i) Addition of water to the beans on the drying floor.
(ii) Rubbing beans with bags to remove excessive mucilaginous material.
(iii) Addition of small quantities of paraffin oil to the beans in the rotary dryer.
(iv) Steeping the beans in water, both hot and cold, at the end of the fermentation period and before drying commenced.
(v) Complete sun drying and complete drying in rotary hot air machines and combinations of both techniques.
(vii) Rapid drying by mechnical means.
(viii) Slow drying by mechnical means or by sun, and combinations of both.
(ix) Drying on a heated floor.

As a result of these trials, several variations of the standard fermenting and drying methods were devised. The most important innovation recommended is the introduction of a carefully controlled " resting phase " shortly after the initiation of fermentation. The inclusion of this so-called " resting phase " (which is in fact a period of intense microbial activity), when the beans are taken from the sweat boxes and spread thinly on a floor under cover before being returned to the sweat boxes to continue fermentation, has led to the production of fermented beans of more consistent quality than any other method yet devised.

The method allows a period of viability of 32 to 36 hours. Following a short " resting phase " (about six hours) the beans are placed in a long shallow box and the temperature rises sharply to 42 to 46° C., by the end of this phase nineteen to twenty hours later. At the same time cotyledon pH is brought to approximately 4.5. The " resting phase " in conjunction with the initial shallow fermentation quickly brings the beans to the conditions giving the maximum possible anthocyanin destruction. When the beans are returned to the normal sweat boxes, the temperature quickly rises further to between 45° C. and 50° C. and the destruction of anthocyanin continues during the next 48 hours, during which oxygen uptake is minimized. On the three remaining days of fermentation, oxygen uptake is encouraged but a safe level of acidity to prevent putrefaction is maintained. During this period the beans show an increasing amount of browning and when fermentation is complete, very little purple pigmentation remains. The method is not perfect but produces more consistent quality than any other method yet devised.

The two crucial points in the application of the " resting phase " are the definition of the end point of this phase and the economics of providing additional floor space necessary for spreading the beans. Current experiments are concerned with these two points. An attempt is being made to establish the weight per cubic foot of beans as the criterion on which to base the length of the " resting phase ". Experiments are also proceeding to determine whether a somewhat lengthened " resting phase " coupled with a greater depth of beans can produce comparable results so that the size or number of resting floors required may be reduced. Promising results are being obtained.

Coconut Improvement.

Coconut products rank first amongst the exports of Papua-New Guinea and the coconut palm is also of great importance as a Native food crop. However, little work had been carried out on a systematic basis prior to 1954 when an Agronomist was appointed to work specifically on the coconut. In commencing a programme of improvement, two approaches were considered:

(*a*) the improvement of existing palm stands,

(*b*) the provision of improved seed for new plantings.

A survey of literature was made so that full advantage could be taken of findings from other parts of the world but indications were that there has been less scientific study of the coconut than of any other crop plant of comparable importance and much remains to be done, even on many of the basic agronomic problems.

With regard to cultural practices, experiments in different parts of the world have shown responses to fertilizing with potash, phosphorus, nitrogen, lime and farmyard manure and under certain conditions yield improvements have also been obtained from ploughing or forking the soil.

Regarding the provision of improved planting material, from the results of a critical experiment carried out in Ceylon, it seems highly probable that the traditional method of improvement of planting material is ineffective. This experiment showed that the use of seed from high yielding mother palms gave no significant improvement even where the mother palms had been selected following years of careful observation. The same experiment demonstrated, however, that a definite improvement could be achieved by nursery selection of seedlings.

The general conclusion from this survey of literature was that genetic improvement of planting material would be a very long term project. At the same time it was apparent that the condition of existing stands in many parts of the Territory left much to be desired. Many of these are declining in productivity as well as being of obviously unhealthy appearance. This condition is not usually wholly explicable on the basis of senility although old age is commonly a partial cause.

It was therefore decided that in the programme of coconut improvement, work should be concentrated initially on the improvement of existing palm stands. At the same time, the problem of providing improved seed has been given attention and a breeding programme has been initiated. Much of the work is carried out in the different coconut growing areas of the Territory but as the Agronomists concerned with coconut improvement are stationed at Keravat, their work will be reported here.

Coconut Agronomy.

Cultural Trials.

Fertilizers.

In areas where palm growth and copra yields are less than optimal, surveys have been made relating the condition of the palms to the type of soil and subsequently fertilizer trials have been laid down on representative soil types. The general aim of these trials has been to determine what elements may be deficient in the soils and whether the deficiencies may be corrected economically by the use of inorganic fertilizers. Economic considerations are of major importance. Reports have been published of this work as follows:—" Coconut Experiment Work in New Ireland. I. Field Survey and Introduction "—A. E. Charles. *Papua and New Guinea agric. J.* **11**, (3): 89–94 (1959), " Coconut Experiment Work in New Ireland. II. Progress Report on Field Trials "—A. E. Charles. *Papua and New Guinea agric. J.* **11**, (3): 116–120 (1959). and " Coconut Agronomy 1954–58 "—A. E. Charles. *Papua and New Guinea agric. J.* **12**, (3): 28–36 (1960).

Comprehensive Fertilizer Trials.—These are primarily diagnostic but the levels of fertilizer applied are such that some indication should be given as to the economics of any responses obtained. These trials involve all the main plant nutrients.

New Ireland.—Trials were laid down in 1955 on palms growing on clay-loam soils derived from coral. Fertilizers tested are lime (for pH control) and sources of N,K,P, Mg,Cu and Mo individually, plus a minor element mixture containing Fe,Zn,Mn,Co and B. Design is a half-replicate of 2^7 factorial, on sub-blocks with and without lime. Lime is broadcast on sub-blocks of eight palms (4 x 2) surrounded by a single guard row of untreated palms. For the other elements a single palm plot is used with no guarding. These fertilizers are placed in a ring extending only about 4 feet from the base of the palms, in order to minimize " poaching " between plots. Fertilizer is applied at intervals of two years, except for N which is applied every six months. Yield records (counts of developing nuts on the palms) are made every six months.

Two sites were chosen for the comprehensive trials:

Red-brown Clay-loam. This was a better type of soil, only slightly acid, usually carrying healthy palms. The site chosen was close to the sea with palms less than 30 years old. Yield was estimated at 12 to 13 cwt./acre/annum of copra at the commencement of the trial. Plate 7 illustrates a typical healthy coconut plantation in New Ireland.

Yield recording was commenced in November, 1955, and fertilizer was applied in May, 1956, and again in May, 1958. Records up to November, 1959, showed no significant response to any element. There was an indication of possible response to nitrogen in nut counts at May, 1959, but this was not sustained in November, 1959, and it was decided to conclude the trial at this stage. It is evident that on these better soils fertilizing is unnecessary. Even if the nitrogen response were real, it would be preferable to establish a legume cover crop rather than applying fertilizer.

Yellow-brown Clay-loam. This was an acid soil, where palms were typically varied in appearance but poor on the average. The site chosen was about a quarter mile inland with palms less than 30 years old. Many palms were yellow and carried very few nuts. Yield was estimated at 5 to 6 cwt. per acre at the outset.

Yield recording was commenced in November, 1955, and fertilizer applied in November, 1955, and again in November, 1957.

The only response obtained was to muriate of potash, which had been applied at the rate of 2 cwt. per acre (4½ lb. per palm). This gave improvement both in yield (Table 8) and appearance of treated palms relative to untreated. However, the palms which received potash have not attained a fully healthy appearance.

TABLE 8.—RESPONSE TO POTASH ON YELLOW-BROWN CLAY LOAM SOILS, NEW IRELAND.

NUMBERS OF NUTS PER PALM.

Treatment.	11/55.	5/56.	11/56.	5/57.	11/57.	5/58.	11/58.	5/59.	11/59.	6/60.
No K	47	41	30	18	32	36	32	25	33	35
K	47	40	33	27	41	41	38	30	41	41

The response first appeared twelve months after application of fertilizer but did not reach statistical significance till eighteen months. Since this response was only in the developing nuts on the palms, actual increase in copra could not be expected till about two years after fertilizing. The response from May, 1957, to June, 1960, has averaged about twelve nuts per palm per annum, or about 4 lb. copra per palm (nut size is small and has not improved appreciably with fertilizing). This would mean a return of 1.8 tons of copra for 1 ton of fertilizer applied. The return might be economic if copra prices were good, but is not clear enough for a firm recommendation to be made.

Following failure of response to elements other than potash, coupled with failure of chemical analyses of soils and plant material to detect deficiencies of other elements, the design of the trial was altered from November, 1959. Other fertilizers were discontinued and potash supplied to an additional set of plots (those which had previously received Mo, to which there had been no response).

PLATE 7—*A typical scene in a New Ireland coconut plantation.*
[Photograph Australian News and Information Bureau]

PLATE 8—*Interplanting mature coconuts with cacao has proved very successful in many parts of Papua and New Guinea.*
[Photograph Australian News and Information Bureau]

Rate of application was increased to 8 lb. per palm. This new arrangement gives four groups of 32 palms each, viz.:

Control—no K applied.

K applied 1955 and 1957 only—these will be followed for residual effects.

K applied only in 1959.

K applied 1955, 1957 and 1959.

Papua.—Soils here are non-acid and lime was replaced by gypsum purely as a source of Ca. This meant that all fertilizers could be applied on single palm plots and the design of the trial is therefore a quarter replicate of 2^9. Elements used are K, P, N, Ca, Mg, Mo, Cu, Zn individually plus a minor element mixture containing Fe, Mn, Co and B. Otherwise the trials are the same as in New Ireland.

Two sites were chosen:

Black Sand. The site chosen was close to the sea, with tall palms over 40 years of age. Most appeared healthy but some showed pronounced yellowing of the older fronds. Initial yield was estimated at 11 cwt. per acre with a copra out-turn of about 4,900 nuts per ton.

Yield recording was commenced in March, 1957, and fertilizer applied in October, 1957, and October, 1959.

TABLE 9.—POSSIBLE RESPONSE TO NITROGEN ON BLACK SAND SOILS, PAPUA.

NUMBERS OF NUTS PER PALM.

Treatment.	4/57.	10/57.	4/58.	10/58.	4/59.	10/59.	4/60.
No N	35	39	42	38	32	27	32
N	39	39	44	42	37	29	35

There has been no clear response so far to any element. Only nitrogen has shown any response (*see* Table 9) but at its highest (about five nuts per palm in March, 1959) it would be too small to be economic and may not have been a real fertilizer effect. The appearance of the palms in the trial area appeared to have improved relative to those surrounding the block, but this improvement was not linked with any specific fertilizer treatment. This could have resulted from " poaching " between plots, which would lead to improvement of palms to which fertilizer had not been applied directly, or response to some element in the fertilizers which had not been considered as a fertilizer. The only likely element is sulphur which was contained in most of the materials used.

The latter theory was given some support by analogy with a condition in New Britain where yellowing of palms was suspected to be caused by sulphur deficiency. However, analysis of foliage from very yellow palms near the black sand trial area showed an apparently normal sulphur content.

Alluvial Brown Loam. Palms on the site chosen were well grown and fairly healthy in appearance and initial copra yield was estimated at 12 cwt. per acre.

Fertilizer was applied in March, 1957, and again in March, 1959. The only promise of response was to the minor element mixture but this disappeared in March, 1960, so was not considered real (Table 10).

TABLE 10.—POSSIBLE RESPONSE TO MINOR ELEMENT MIXTURE ON ALLUVIAL BROWN LOAM, PAPUA.

NUMBERS OF NUTS PER PALM.

Treatment.	4/57.	10/57.	4/58.	10/58.	4/59.	10/59.	4/60.
No minors	33	42	41	34	30	28	34
Minors	34	40	41	38	35	32	34

It appears that fertilizing on this soil type could not be generally recommended and probably most problems arise from bad water relations rather than nutrient deficiency.

Specific Fertilizer Trials.—Following results obtained in diagnostic trials, supported by analytical data, more specific trials have been laid down to test the most effective methods of utilizing individual fertilizers.

New Ireland.—The comprehensive trials showed a response to muriate of potash but the return was barely economic. Three further trials have been commenced with potash:

Rates of Application. The failure of palms in the comprehensive trial to regain full health suggested that higher rates of application might be needed. This trial aims to determine economic levels of potash application.

Four levels are used, 0, 2½, 5 and 10 lb. per palm of muriate of potash, applied annually. Design is a randomized block with four replications. Plots are nominally of sixteen trees (4 x 4), surrounded by a single untreated guard row. Fertilizer was broadcast over a ring extending about 6 feet from the base of the palm, after cutting back of grass and cover crop.

The site selected was a typical yellow-brown clay-loam soil with very variable palms. Palms were over 40 years old and overall of poor appearance with many gaps in the stand. Actual plot size averages only twelve palms and of the 189 originally included in the trial, six have died in the two years it has been running. The area has been planted with *Leucaena glauca* in the coconut lines and cacao was planted under this shade in 1958. Like the coconuts, these crops are in very variable condition.

TABLE 11.—POTASH RATE OF APPLICATION TRIAL, NEW IRELAND.

NUMBERS OF NUTS PER PALM.

Rate per palm.	6/58.	12/58.	6/59.	12/59.	6/60.
0	14.0	20.6	15.7	15.1	14.4
2½ lb.	12.1	17.9	16.8	17.3	21.0
5 lb.	12.1	18.0	14.9	17.5	21.8
10 lb.	20.1	25.1	21.8	24.7	29.3

Nut counts were commenced in June, 1958, and fertilizer was applied in December, 1958, and December, 1959. Table 11 shows numbers of nuts per palm for each treatment. These results have not yet been analysed statistically. While firm conclusions cannot be drawn as yet, it is of interest to note that the increases due to potash eighteen months after application do not appear to be appreciably affected by the rate of application. However, there was a differential uptake of potash in the first twelve months after application, as shown by analysis of leaves taken from one palm in each plot (Table 12).

TABLE 12.—POTASH RATE OF APPLICATION TRIAL, NEW IRELAND.

PERCENTAGE POTASH IN FRONDS.

Rate per palm.	12/58.	6/59.	12/59.
0	0.62	0.68	0.70
2½ lb.	0.67	1.02	1.09
5 lb.	0.66	1.01	1.32
10 lb.	0.64	0.96	1.69

Methods of Application. In the comprehensive trials, fertilizer was applied in a narrow band around the base of the palm to avoid poaching. This placement might be less effective than a wider spread of fertilizer, since the high concentration would tend to burn the root rather than being taken up. Frequency of application also needs investigation, since leaching rate is heavy and two-yearly dressings may not be frequent enough.

The aim of this trial is to test the efficiency of three different methods of application, all at the same net rate of potash. Treatments are:

(i) Control—no fertilizer.

(ii) 4 lb. muriate of potash per palm, in narrow band. Applied at two-year intervals.

(iii) 4 lb. muriate of potash per palm, broadcast over a broad ring. Applied at two-year intervals.

(iv) 2 lb. muriate of potash per palm, broadcast over a broad ring. Applied annually.

Treatment (ii) corresponds to the treatment used in the original comprehensive trial. Design of this trial is a randomized block, with six replications. Plots are nominally of ten trees (5 x 2) surrounded by a single untreated guard row.

The site selected was a block of palms previously used for a cultivation trial in which there had been no response to the treatments. However, the new fertilizer treatments were arranged so as to avoid any possible influence of the previous cultivation treatments. Palms were over 40 years old and in variable, but generally poor, condition.

Fertilizer was first applied in December, 1958, and the fourth treatment repeated in December, 1959. Nut counts on these palms had been maintained since November, 1955. Table 13 shows pre-treatment and post-treatment yields.

TABLE 13.—POTASH METHOD OF APPLICATION TRIAL, NEW IRELAND.

NUMBERS OF NUTS PER PALM.

Treatment.	Average 12/55 to 12/58.	6/59.	12/59.	6/60.
i	21.8	18.1	16.2	15.2
ii	27.9	24.5	23.6	26.5
iii	16.8	15.0	17.6	20.1
iv	24.4	22.5	23.9	23.0

The results have not yet been statistically analysed, but it appears that the third treatment has given the greatest response. These results do not tie in very well with those of the rate of application trial, since from the latter it might be expected that the fourth treatment would be as effective as the third.

Seedlings. The time taken by a young seedling to come into bearing is of considerable economic importance and if fertilizing can reduce this period it could be very profitable. This applies particularly in replanting areas where the old palms show nutrient deficiency. In fact, on soils such as the potash-deficient yellow-brown clay-loams of New Ireland, it is probable that fertilizing would be essential for healthy growth of the replants. This trial aims to measure the growth response to potash of seedlings grown in such an area.

The trial is superimposed on the New Ireland replanting trial (described below), on a split-plot basis, half of each plot being left untreated as a control.

The seedlings were transplanted in January, 1959, after about 6 months in the nursery. Muriate of potash was applied at the rate of 4 oz. per palm in June, 1959, and a further 6 oz. per palm in December, 1959. Measurements of growth, made at six-monthly intervals, consisted of the numbers of new leaves formed and the height of the tallest new leaf. Measurements for December, 1959, and June, 1960, are shown in Table 14. These show an appreciable, and increasing, response to the fertilizer.

TABLE 14.—POTASH FERTILIZING OF SEEDLINGS, NEW IRELAND.

Treatment.	Number New Leaves.		Height (inches).	
	12/59.	6/60.	12/59.	6/60.
No K	3.79	4.10	61	77
K	4.04	4.51	65	92

Leaf samples for chemical analysis were also collected from treated and untreated plots. The sample taken was two central leaflets from the youngest fully opened fronds of six seedlings. Average potash content of leaves from untreated seedlings was 0.98 per cent., and from treated seedlings 1.79 per cent., in December, 1959. This difference was highly significant.

New Britain.—In the Gazelle Peninsula of New Britain, coconuts are grown extensively on pumice soils which are usually highly fertile. Since the war, large areas have been interplanted with cacao. Growth of two crops in conjunction is likely to put a heavy drain on soil nutrients and there have been indications of declining copra yield and unhealthy appearance of the cacao where the two crops have been grown together for ten years and more.

A comprehensive fertilizer trial on sole cacao had shown no response to any element other than nitrogen. At the same time, chemical analysis of pumice soils indicated that phosphorus is sometimes rather low though potash is very well supplied.

A nutritional trial was therefore planned, using the following treatments:

Nitrogen: 0, 1 cwt./acre and 2 cwt./acre of sulphate of ammonia.

Phosphorus: 0 and 1 cwt./acre of superphosphate.

Design of the trial is a 3 x 2 factorial. Plots are of nominally 16 coconut palms (4 x 4), surrounded by a single guard row, and the included cacao. Yield recording is by six-monthly nut counts on the coconuts and counting of pods at each cacao harvest (at 3 to 5 week intervals, depending on crop).

The site chosen is a block of about 40 year-old coconuts under which cacao has been growing for 10 years without additional shade. The cacao is planted somewhat irregularly, so that the number of cacao trees per plot varies, but averages about 50.

Yield recording was commenced in January, 1958, and fertilizer applied in August, 1958, and again in July, 1959. The fertilizer was broadcast around the cacao trees only but the ubiquitous coconut roots should have obtained a share of it.

Up to January, 1960, there had been no appreciable response in nut numbers on the coconuts. (Table 15).

TABLE 15.—NITROGEN-PHOSPHORUS TRIAL ON INTERPLANTED CACAO-COCONUTS.
NUT NUMBERS ON COCONUTS.

Treatment.	1/57.	8/58.	1/59.	7/59.	1/60.
N_0	47	38	35	32	33
N_1	46	38	35	34	34
N_2	45	36	32	31	32
P_0	45	38	33	32	33
P_1	47	36	35	32	33

With cacao, there was a significant response to nitrogen only in March and April, 1959, between 6 and 8 months after fertilizer application. However, the level of response was not maintained in later months and for the period March to December, 1959, was only 10 per cent. (Table 16). It has therefore been decided to increase rates and frequency of nitrogenous fertilizer from July, 1960.

TABLE 16.—NITROGEN-PHOSPHORUS TRIAL ON INTERPLANTED CACAO-COCONUTS.
NUMBERS OF CACAO PODS HARVESTED.

Treatment.	Pre-Treatment 17th February, 1958 to 4th August, 1958.	Early Post-Treatment 23rd March, 1959 to 6th April, 1959.	Post-Treatment 23rd March, 1959 to 24th December, 1959.
N_0	16,795	2,271	22,722
N_1	16,665	3,300	23,125
N_2	15,514	3,586	24,810
P_0	24,689	4,334	35,796
P_1	24,285	4,823	34,861

Cultivation.

The usual practice in this Territory is for plantation maintenance to be restricted to cutting of the ground cover with no cultivation of the soil. Other countries have reported benefits from cultivation and a trial was therefore laid down on the Government Plantation at Baibara, Papua, to test the effects of cultivation on palm yields.

Original treatments were:

(i) Control—no cultivation.

(ii) Disc-harrowing every six months.

(iii) Strip ploughing—a strip about 15 feet wide ploughed down the centre of alternate rows in alternate years.

These treatments are fairly mild as over-intensive cultivation might set the palms back through damage to the roots. Erosion is also likely to occur if soil is left exposed for long periods.

Design of the trial is a randomized block with four replications. Plot size is 36 (6 x 6) palms without guarding.

The site chosen is an alluvial brown loam, a medium heavy soil in which the bulk of the roots tend to be concentrated in the top foot of soil. Palms are planted at 30 feet on the triangle and are in healthy condition. Yield recording is by counting the nuts on the ground each time the area is harvested.

The trial was commenced in 1957. It was found that the disc-harrows failed to penetrate the soil appreciably and merely disturbed the ground cover, which consisted mainly of short grasses and legume with scattered *Imperata* and *Mimosa pudica*. It was found as the trial proceeded that harrowing did reduce the *Imperata* grass.

Up to October 1959 there was no response evident to either cultivation treatment. (Table 17).

TABLE 17.—CULTIVATION TRIAL, PAPUA.

NUMBER NUTS HARVESTED.

Treatment.	Pre-treatments (to May, 1957).	May to December, 1957.	January to December, 1958.	January to September, 1959.
Control	4,343	3,162	9,780	8,241
Harrow	3,891	3,243	10,063	7,864
Plough	4,102	3,360	10,104	8,119

It was therefore decided to replace the harrow treatment with more intense cultivation, and in March 1960 the plots which had previously been harrowed were ploughed completely in two directions. The strip-plough treatment is being continued unchanged.

Maintenance.—The maintenance trial located at Baibara was designed to test the comparative costs of three different methods of cover maintenance as well as to observe how effective was each method from the point of view of finding fallen nuts and eliminating undesirable plant species. The three methods compared were cattle grazing, tractor and drag, and hand-slashing, the last being the method most commonly employed in the Territory. Each method was tested on blocks of approximately 35 acres. The original cover was a dense mixture of grasses, mainly kunai (*Imperata* spp.), thurston (*Paspalum conjugatum*), couch (*Cynodon* sp.) and *Paspalum paniculatum*; sensitive plant (*Mimosa pudica*), " clover " (*Desmodium heterophyllum*), *Centrosema pubescens* and scattered clumps of fern.

The different treatments have brought about some change in the botanical composition. Cattle grazing has reduced the *Imperata* and *P. paniculatum* but the amount of fern has increased. With dragging, the *P. paniculatum* has increased greatly and in patches it completely dominates the other grasses while *Centrosema* has also become more prominent in other patches. Hand-slashing has caused little change beyond perhaps a slight increase in *P. paniculatum*.

Sufficiently intense cattle grazing keeps the pasture very short so that nuts can be found with the greatest of ease. However, it must be supplemented by hand or machine grass cutting during the wet season when the bulk of pasture growth is too great for the cattle to handle. The drag also helps in locating nuts as it collects all that lie in its path and carries them along for some distance before lifting over them and leaving them in a heap. However, there is a tendency for the build-up of a dense mat of organic matter on the surface and this is slow to decompose.

Costing of grass maintenance by cattle grazing is complicated and has not been calculated. Hand-slashing costs 8s. to 10s. per acre per operation whereas dragging at Baibara costs from about 7s. to 12s. per acre depending on weather conditions. On plantations with a

good legume cover crop, a lighter drag which would keep costs down should be effective. The trial has recently been discontinued as it is unlikely that further valuable results will emerge.

Replanting.—Since a large proportion of the palms in the Territory are at least 50 years old, replanting will have to be carried out on a large scale during the coming years if productivity of these stands is to be maintained.

Planters, in New Ireland particularly, have made a start on replanting by planting seedlings in the centre of the rooms between old palms. A trial was desirable to determine the effect of the old stand on growth of the new seedlings, and whether thinning or removal of the old palms would lead to quicker and better growth of the replants.

The trial is designed to test the effect of different levels of thinning of the old palms, from nil to complete removal. Initial thinning was carried out before planting the seedlings because felling and removal of old palms was thereby facilitated and it was thought that shading might adversely affect seedling growth from the earliest stages. Nut counts are made on palms remaining in the thinned plots, to determine whether loss of crop from removal of some palms might be offset to a certain extent by heavier bearing of those which remain. Design is a randomized block with wide guarding of plots to avoid shade influence of the old palms overlapping from plot to plot.

The trial was laid out on two areas:

Baibara, Papua.—A trial was laid down on a large scale on the Government Plantation at Baibara. Five treatments were used:

(i) No old palms removed.

(ii) ¼ old palms removed.

(iii) ½ old palms removed—alternate rows in east-west direction.

(iv) ¾ old palms removed.

(v) All old palms removed.

There are four replications. Plot size is 36 (6 x 6) old palms, surrounded by a double guard of palms receiving the same treatment—thus, for thinning purposes, plot size is 10 x 10. The inner plot includes within it 30 replant seedlings.

The site chosen is planted at 30 feet on the triangle, and the palms, at about 45 years of age, are healthy and vigorous and throw a fairly dense shade. The stand was not one in which replanting was yet necessary but was chosen because of suitability for experimental purposes.

The site was selected and nut counts commenced in April, 1958. A nursery was prepared in August, and the area was holed and thinning treatments carried out in October, 1958. Transplanting of the seedlings was delayed by dry weather but was carried out early in 1959. Replacements have been made as necessary. Seedling growth is measured at six month intervals, measurements being the numbers of new leaves formed and the height of the tallest new leaf.

Seedling growth to date is summarized in Table 18 and nut numbers in Table 19.

TABLE 18.—REPLANTING TRIAL, BAIBARA.

SEEDLING GROWTH.

Treatment.	April, 1959.		September, 1959.		April, 1960.	
	a	*b*	*a*	*b*	*a*	*b*
No thin	4.9	32	2.5	40	3.6	52
¼ thin	4.6	31	2.8	39	3.7	52
½ thin	5.2	34	2.8	40	3.8	47
¾ thin	5.3	34	2.5	37	3.6	45
Full thin	5.1	37	2.9	43	4.0	51

a. = Number new leaves since last measurement (for April, 1959, since germination).

b. = Height of tallest new leaf (inches).

TABLE 19.—REPLANTING TRIAL, BAIBARA.

NUMBERS OF NUTS PER PALM.

Treatment.	4/58.	9/58.	4/59.	9/59.	4/60.
No thin	49.1	43.8	36.4	30.5	39.7
¼ thin	43.9	38.3	36.6	36.6	39.2
½ thin	41.0	38.6	33.2	32.3	35.6
¾ thin	46.7	39.3	37.9	32.8	30.4

New Ireland.—This trial has three replications of four treatments, the ¾ palms-removed treatment not being included.

The site chosen is on a private plantation where palms are planted at 33 feet on the square. Palms are about 50 years old and not very healthy, so they do not throw so heavy a shade as palms at Baibara. The stand is declining and ready for replanting. Soil is of yellow-brown clay-loam type but the palms are rather better than average for this soil. Plot size is 25 (5 x 5) old palms surrounded by a double guard, thus for thinning purposes plot size is 9 x 9. Replants are planted more closely than the original palms, in the centre of the lines in one direction but spaced at 26 feet in the opposite direction. Thus new seedlings are planted at 33 ft. x 26 ft. Thirty seedlings are included in the inner plot.

The site was selected and nut counts commenced in June, 1958, and thinning and planting were carried out in December, 1958. Replacements have been made as necessary and measurements are made of seedling growth at six-monthly intervals as at Baibara.

Seedling growth is summarized in Table 20 and nut numbers in Table 21.

TABLE 20.—REPLANTING TRIAL, NEW IRELAND.

SEEDLING GROWTH.

Treatment.	June, 1959.		December, 1959.		June, 1960.	
	a.	*b.*	*a.*	*b.*	*a.*	*b.*
No thin	4.3	48	3.9	63	4.3	83
¼ thin	4.5	48	3.8	63	4.2	80
½ thin	4.7	48	4.1	64	4.5	90
Full thin	4.6	47	3.9	62	4.5	86

a. = number new leaves since last measurement (for June, 1959, since germination).
b. = height of tallest new leaf (inches).

TABLE 21.—REPLANTING TRIAL, NEW IRELAND.

NUMBER OF NUTS PER PALM.

Treatment.	6/58.	12/58.	6/59.	12/59.	6/60.
No thin	39	43	27	19	25
¼ thin	45	50	30	19	27
½ thin	38	42	23	22	21

Considering both trials together, it is evident that the presence of the old palms has had no appreciable effect on growth of the replants for the first twelve months at least, nor is there any sign that yield of palms in thinned plots has increased.

Interplanting with Cacao.—A trial was commenced at Keravat in 1955 which aimed to compare the costs of establishment of, and returns to be expected from, coconuts and cacao as sole crops or grown together (i.e. cacao grown under coconut shade). Interplanting is illustrated in Plate 8. For interplanting, coconuts require a few years' start, otherwise they are over-shaded in the early stages by the shade for the cacao. Accordingly four treatments were included, viz.:

(i) Sole coconuts.
(ii) Sole cacao, planted at the same time as the coconuts.
(iii) Coconuts later to be interplanted with cacao.
(iv) Sole cacao, to be planted at the same time as interplanted cacao.

Comparison between the third and fourth treatments would directly show any special influence of coconuts on the growth of young cacao.

The design is a randomized block with four replications. Coconuts were planted at 30 feet on the triangle, cacao at 15 feet. Plot size is 20 coconuts (4 x 5), 80 cacao, or 20 coconuts plus 60 cacao, surrounded by guard rows of a single line of coconuts or two of cacao.

Initial plantings of coconuts and cacao were made in 1955–56. However, damage to the coconuts by *Oryctes rhinoceros* has been extremely heavy, and it was soon realized that the trial would not give satisfactory figures for costs of establishment of coconuts. The original planting included 315 palms but replacements have numbered 230 and not more than half of them could yet be said to be satisfactorily established. Those which have survived have been severely retarded and only one or two palms have yet commenced to flower. It will be some years before the coconuts can be expected to form a reasonable stand and the best that can be hoped from the trial is that it may ultimately give comparative yield figures for the two crops grown separately and in conjunction. The cacao plots of the second treatment have grown well and most of the trees are now bearing.

Improvement of Planting Material.

Progeny Trial.

A review of the literature on coconut breeding led to the conclusion that the only reliable method of detecting prepotent parent palms is by progeny testing. Thus a trial has been laid down at the Government Plantation, Baibara, Papua, to test parent palms from that plantation.

Design of the trial is a 3 x 3 balanced lattice with four replications. Plots are of 12 palms (4 x 3) and spacing is 30 feet on the square. Nine progenies are included in the trial; in the single guard line planted around the outside of the block, progenies of another 8 palms are planted for observation and visual comparison. Progenies are from open-pollinated seed with the male parent unknown. This should give a good measure of the general combining ability of the parent palms.

Parent palms were chosen in March, 1957, most being chosen simply for vigour and desirable nut characters, though one or two were included with less desirable nut type to give some idea of the inheritance of these characters. A nursery was established and seed added to it as it became available.

Considerable difficulty has been experienced in establishing the trial, partly because of the necessity of planting a full replication at the one time—shortage of seedlings from one parent can delay the whole programme. This has meant keeping many seedlings in the nursery beyond the best planting age and with frequently unfavourable weather conditions, losses after transplanting have been high. Two replications were planted out in May, 1958, and 90 per cent. of seedlings in these two blocks are now satisfactorily established. The remaining two replications were planted in April, 1959, but very few of the seedlings survived, and replacements planted in October, 1959, fared little better. Further replacements were made in April, 1960. An additional complication is that one of the parent palms has died since the commencement of planting.

Detailed records are maintained of germination and seedling growth of the progenies. Yield records are also kept of the parent palms for ultimate comparison with their offspring.

Seed Sources Trial, Keravat.

This trial aims to compare palms raised from seed obtained from different localities in the Territory, to determine whether any local strain may be superior in yield, earliness of bearing or other economic characters.

Design of the trial is a 3 x 3 balanced lattice with four replications. Plot size is 16 palms (4 x 4) planted at 30 feet on the triangle. There is no internal guarding but the block is surrounded by a single line of palms to reduce edge effect.

Site of the trial is at some distance from the main planted area at Keravat, at an elevation of a few hundred feet, and it is hoped that *Oryctes* will not be a major problem. Virgin bush was cleared for the trial.

Seed nuts were collected from plantations in the following localities:

Papua.
Karkar Island.
Madang District (New Guinea Mainland).
New Ireland.
Markham Valley (New Guinea Mainland).
Bougainville.
Hermit Islands.
Sepik District (New Guinea Mainland).
Gazelle Peninsula (New Britain).

Seed was collected at random on these plantations, but only freshly fallen, fully mature, ungerminated nuts were taken. An exception to this rule was made with the Markham Valley nuts. In this area there are palms which carry very large nuts but these palms are not found in a pure stand. Large nuts were therefore deliberately selected. All seed nuts were measured and weighed and average sizes are shown in Table 22.

TABLE 22.—SEED SOURCES TRIAL.

SIZE OF NUTS—AVERAGE WEIGHT AND DIMENSIONS.

Source of Seed.	Weight (lbs.).	Length (inches).	Diameter (inches).
Markham	4.35	10.0	8.0
Karkar Island	3.34	9.1	7.0
Sepik	3.2	9.0	7.3
Gazelle Peninsula	2.73	8.5	6.4
Madang	2.61	8.7	7.1
Bougainville	2.53	8.6	6.5
Papua	2.29	8.9	6.6
New Ireland	1.91	8.0	5.9
Hermit Islands	1.57	9.0	5.6

It should be noted that weight is not completely comparative since the moisture content of the husk varies considerably.

Seed nuts were collected between October, 1958, and April, 1959, and planted in a nursery at Keravat. Detailed notes of germination were made, and a summary of the observations is shown in Table 23.

TABLE 23.—SEED SOURCES TRIAL.

GERMINATION OF SEED NUTS.

Source of Seed.	Total per cent. Germination.	Weeks to Reach 50 per cent. Germination.
Karkar Island	91	7
Gazelle Peninsula	87	11
Hermit Islands	87	13
Madang	85	12
Bougainville	84	11
Sepik	84	11
Papua	79	11
Markham	76	10
New Ireland	69	15

The time for germination was measured from the time of collection of seed, which would have been within one or two weeks of the nuts falling from the palms. There were marked differences between some of the strains. However, the comparison may not be completely reliable, since conditions between collection of the nuts and their arrival at Keravat were not always uniform. This applies particularly to the poor performance of Hermit Islands and New Ireland nuts.

Growth of the seedlings at six months of age was measured, and they were classified as " selected " or " reject " on their vigour and appearance. A summary of these data is given in Table 24.

TABLE 24.—SEED SOURCES TRIAL.

GROWTH OF SEEDLINGS AT SIX MONTHS.

Source of Seed.	Mean Number of Leaves.	Mean Girth.	Mean Height (inches).	Per cent. Selected Seedlings.
Karkar Island	6.1	4.6	50.2	77
Papua	4.3	3.4	45.7	52
New Ireland	4.3	2.8	29.5	44
Madang	4.2	3.5	39.3	76
Gazelle Peninsula	4.1	4.1	43.5	69
Markham	3.5	3.0	37.3	51
Bougainville	3.4	3.1	34.7	54
Hermit Islands	3.4	2.7	27.7	49
Sepik	3.4	3.2	38.3	64

Seedlings were transplanted between August and November, 1959, with good planting conditions prevailing. Most received some setback but deaths were low. The Karkar Island seedlings, which grew very vigorously in the nursery and possibly largely exhausted their food reserves, were severely checked by transplanting. Fungal leaf disease caused some damage in the early stages.

Crossing of Tall and Dwarf Palms.

Yellow dwarf coconuts were hand-pollinated with pollen from Markham coconuts (growing at Keravat) in January and July, 1957. Twelve nuts from these crosses were harvested in 1958, and planted in the nursery at Keravat. Ten germinated, but one subsequently died. The seedlings were transplanted to the field in 1959, together with two open-pollinated seedlings for comparison. Observations will be made of economic characters of the hybrids.

Pollen Studies.

Preliminary studies were made into means of storing pollen for prolonged periods to facilitate the maximum utilisation of prepotent palms and also to enable shipment of pollen from one country to another for breeding purposes. Pollen was found to retain some viability after several weeks storage in the freezing cabinet of a domestic refrigerator, but difficulties were encountered in finding a suitable medium to germinate the pollen for assessing viability.

Observations and Surveys.

Lightning Strike.

Lightning strike causes greater cumulative losses of palms in most Territory plantations than pests or diseases and observations are being made on the cause of death, in particular to determine whether anything can be done to save the ring of palms surrounding the original strike. When a palm is struck, anything from 20 to as many as 60 adjoining palms usually die in succeeding months. Preliminary observations of this phenomenon have been published (*See* " Coconut Lightning Strike "—A. E. Charles. *Papua and New Guinea agric. J.* **12**, (4): 192–195 (1960)) but two interesting observations were made on a recent strike. In one instance it was found, shortly after the strike, that many palms, which outwardly appeared perfectly normal, could be shown to be affected by cutting the outer surface of the trunk, when the bark proved to be dead. Some of these palms later died, following appearance of typical symptoms (broken and hanging leaves and shedding of fruit). One or two palms, where not all the bark was killed, survived and the dead bark became evident as " stem bleeding ". No palm died which did not show at least bark symptoms within a few weeks of the strike.

In two or three other strikes, it appeared that crown symptoms (breaking of fronds) extended over a greater area than the area of palms actually killed.

Bainings Plantations.

Visits were made in company with the Biochemist to plantations in the Bainings District, New Britain, where there were patches of palms showing extreme yellowing of the fronds, unhealthy overall appearance, poor yield and production of rubbery copra. There was no obvious association of the condition with soil type or water relations and no evidence of disease or pests as the cause. Foliar samples were analyzed but no evidence of deficiency of the major elements was found. Sulphur deficiency appeared possible and an observational trial was laid out on a few trees to see whether application of sulphur fertilizer might improve them.

Abaca (Manila Hemp).

Abaca or manila hemp (*Musa textilis*) was first planted at Keravat in the 1930's and a few pilot commercial plots were established in different parts of New Guinea in the following decade. However, in 1952, during a virus survey of the Territory, it was suggested that the stands of manila hemp at Keravat might be carrying a very mild, possibly non-transmissible, strain of the " Bunchy top " virus. As this virus has not otherwise been recorded in the Territory and *Musa* spp. are important as native food crops, steps were taken immediately to destroy all vegetative material of manila hemp throughout the Territory. Seed was saved from the stand at Keravat and a breeding programme commenced, based on seedlings only. Several importations of seed have been made since that time but no further vegetative material of manila hemp has been brought into the Territory.

From the large population of seedling manila hemp raised in 1952, nursery selections were made primarily on the basis of vigour and selections were planted into the field at a 12-ft. x 12-ft. spacing. As the young plants developed, they were further selected for vigour and tested for fibre production. Those plants which gave a fibre recovery of at least 2½ per cent. were retained for further selection. Fibre samples were tested for tensile strength and only those clones whose fibre had a tensile strength of at least 50 Kg/mm^2 were retained for multiplication. About 1 per cent. of the original population survived this rigid selection and was considered good enough for further trial. The selected clones are now being tested in a series of agronomic trials as follows:—

Clone x *Shade* x *Spacing Trial.*

This trial is designed to compare 16 clones at 3 spacings (8 ft. x 8 ft., 10 ft. 6 ins. x 10 ft. 6 ins. and 13 ft. x 13 ft.). Half of the treatments were shaded by *Crotalaria anagyroides* for about 8 months after planting and the other half were unshaded. The design is a 4 x 4 triple lattice using 6 replicates and 4 plants per plot; all plots are guarded. No results are yet available from this trial.

Clone Testing.

This is a straight-out comparison of yield using 25 selected clones which have passed the requirements for fibre recovery and strength. Spacing is 10 ft. x 10 ft. and large corms were used to establish the trial. The design is a 5 x 5 balanced lattice with 6 replications and 16 plants per plot. No results are yet available.

Test of Potential Commercial Value of a Selected Clone.

One of the most promising selected clones (KT8) has been planted on a ¼ acre at a 10 ft. x 10 ft. spacing to obtain some indication of production and trends which could be expected to show up in a commercial planting. The planting is now 2½ years old and has been in production for 12 months. In this period 481 stems weighing 24,318 lbs. produced 527 lbs. of fibre in six harvests. This is an average of 2.16 per cent. recovery. The percentage recovery has increased with time and appears to be stabilizing at 2.3 per cent. This is a little lower than the 2½ per cent. set originally as the minimum standard for selection; when originally selected, the clone had a fibre recovery in excess of 2½ per cent. and the variation is probably caused by different growing conditions. The block where the present trial is being grown has a higher fertility status than the block where the clones were originally tested. The number of stems harvested has increased from 26 in the first harvest to 138 in the sixth. Even allowing for some edge effect and the common experience that extrapolation from small plots gives an exaggerated estimate of production which might be expected from large commercial areas, the yield of this clone is promising and it should increase markedly over the next two or three seasons.

Breeding and Genetic Investigations.

Manila hemp belongs to the 20 chromosome group of *Musa* known as *Australimusa.* Other representatives of this group are *M. peekelii, M. lolodensis, M. angustigemma* and *M. maclayi.* All of these and several inter-specific hybrids are planted in rows and are being compared for vigour, fibre recovery and fibre quality. The most promising are being used as parents for hybridization and selfing with a view to increasing vigour, fibre yield and quality and in order to have a reserve of disease resistant material should disease become a problem. Some hybrids may have direct use under certain conditions in the Territory.

Selections of *M. textilis* are also being crossed and a programme of inbreeding is proceeding in the hope that heterosis may later be exploited.

Polyclonal Seed Garden.

Twelve corms each of 12 clones have been planted in a randomized lay-out to form a polyclonal seed garden. The resultant seed will be tested to determine whether plants produced from it are sufficiently uniform in vigour, fibre recovery and fibre strength to be used as commercial planting material. Communication problems in the Territory make it difficult to distribute corms to some areas.

However, although limited quantities of clones such as KT8 which are likely to be useful commercially are now available for distribution, little interest has yet been shown by the planting community.

Robusta Coffee (*Coffea Canephora*).

There are two strains of Robusta coffee at Keravat, one a rather mixed strain introduced pre-war and the other consisting of several Besoeki lines brought in from Indonesia in 1954 as clonal seed. After the numerous off-types in the pre-war coffee had been rogued out, the remaining trees appeared to differ little from the Besoeki introductions. However, selected clones of both strains have been propagated as cuttings and are being tested as clones and also as parents for clonal seed. It is not envisaged that Robusta coffee will be grown commercially from cuttings but that superior polyclonal or biclonal seed will be the normal type of planting material. Trials at present under way are as follows:

Clone Testing.

Forty-nine clones selected from both strains on the basis of visual characteristics are being tested in a 7 x 7 balanced lattice with 16 trees per plot and 3 replications. 12 clones are from the Besoeki strain and 37 from the local material. The first cuttings were struck in 1958 and the planting completed in 1959–60; multiple stem pruning is being used. It will be interesting to compare the performance of these clones as such and as parents and should their performance as clones show a sufficiently high correlation with their performance as parents, clone testing will be a short cut in the location of superior parents.

Tests of Combining Ability.

Specific combining ability of selected clones is being tested using hand-crossed seed and a start has been made to test their general combining ability using open-pollinated seedlings derived from a polycross test plot. A larger and more formal trial to test general combining ability will be planted as soon as seed becomes available from this plot in sufficient quantity.

Clonal Seed Production.

As an interim measure until fully tested parents are available, polyclonal seed gardens using untested selected clones have been established at Keravat and are to be established at selected points throughout the Territory where Robusta coffee is grown. Although the seed produced from these gardens may not be much better than bulk seed, it should at least have the advantage of greater freedom from off-types. The first garden was planted in Block 303 in 1958 and consists of 12 cuttings of each of the 12 selected Besoeki clones. The plan is a single 12 x 12 plot on a 10 ft. x 10 ft. spacing arranged so that as far as possible each clone has an equal chance of being pollinated by all the other clones. The same plan is being used on the other stations and is as follows:

TABLE 25.—LAYOUT FOR POLYCLONAL COFFEE SEED GARDEN.

KT1	KT2	KT3	KT4	KT5	KT6	KT7	KT8	KT9	KT10	KT11	KT12
4	8	9	2	12	5	6	11	1	3	7	10
7	11	1	8	10	12	5	4	2	9	3	6
10	4	2	11	8	7	12	6	9	1	5	3
2	6	5	7	1	3	10	9	4	8	12	11
6	9	4	3	11	1	8	7	12	2	10	5
3	4	8	12	7	9	1	5	10	11	2	6
8	3	7	6	2	11	9	12	5	4	10	1
5	12	11	1	6	4	2	10	3	7	9	8
9	5	6	10	3	2	11	1	7	12	8	4
11	1	12	5	9	10	4	3	8	6	7	2
12	7	10	9	4	8	3	2	6	5	1	11

This polyclonal seed garden serves also as the polycross test plot for the production of seed for testing the general combining ability of each clone. New gardens are being established using the selections from the pre-war strain.

Pruning Trial.

A pruning trial will be established shortly with particular emphasis on multiple stem systems including the " arch " system of pruning whereby the main stem of the bush is bent over and three or four verticals allowed to come away from it to form the main framework of the bush.

Coffee species collection plots of *Coffea arabica* and *C.liberica* are maintained on the station. The former species does not perform well at such low altitudes and the latter appears to have little to recommend it for commercial use.

Food Crop Agronomy.

In common with primitive populations throughout the tropical world, the indigenous people of Papua and New Guinea utilize bush fallow or shifting agriculture for subsistence cropping. Rationalization of this system to allow more intensive land usage will become a necessity as the population increases and land tenures are modified. Two major trials, the results of which will have a bearing on this problem, are in progress at Keravat, namely, a soil exhaustion trial and a three-course rotation trial. Both these trials were laid down on good virgin soil from which the rain forest had been recently cleared.

Soil Exhaustion Trial.

The aim of this trial is to crop the soil to exhaustion and then to study the nutrient status of the exhausted soil and to determine the effects of fertilizer and other practices on subsequent cropping. The test crop is sweet potato (*Ipomoea batatas*). There are four treatments and four replications of each treatment. The treatments are, in effect, replications in time to give cross comparisons between plots at progressive stages of exhaustion. The first treatment is continuous sweet potato. In the second, the short term leguminous cover *Phaseolus calcaratus* was grown while the first crop of sweet potato was taken off the first treatment and since that time it has also been under continuous sweet potato. The third and fourth treatments progressively went under continuous sweet potato after second and third crops respectively had been taken off the first treatment, having been held in the meantime under the leguminous crop *Mimosa invisa*. A plan of the trial is shown in Table 26:

TABLE 26.—SOIL EXHAUSTION TRIAL, KERAVAT.

Experimental Design.

Half Year.	Treatment 1	Treatment 2	Treatment 3	Treatment 4
1	SP	P.c.	M	M
2	SP	SP	M	M
3	SP	SP	SP	M
4	SP	SP	SP	SP
Thereafter	SP	SP	SP	SP

Replicated four times in space.

SP = Sweet potato; P.c. = *Phaseolus calcaratus;* M = *Mimosa invisa.*

Ten plantings have now been made and yield has decreased from approximately 12 tons of sweet potato per acre to 1 ton per acre. The decline was not steady but the fall-off became rapid after the sixth planting. The period of maturity of sweet potato has decreased from seven months in new ground to four months in the exhausted ground. Disease and insect pests have ravaged the crop and the fifth planting was destroyed by a virus. The substitution of a more disease-resistant variety of sweet potato and regular treatment with all purpose dust has kept pests and diseases in check since that time.

It is now obvious that the soil has reached virtual exhaustion and a pot test was carried out concurrently with the tenth planting as a preliminary to the superimposition of a fertilizer trial on the plots. In the pot test, a significant response to phosphate was given in the early growth of sweet potato. The response to nitrogen was, surprisingly, negligible, perhaps because of mineralization in the disturbed soil prior to potting.

A fertilizer trial has been superimposed on the current 11th planting using four levels of phosphorus and nitrogen in all combinations. The levels have ranged from no N and no P to 200 lbs. per acre of N and 400 lbs. per acre of P. Each of the ten plots was quartered and

four replications of the fertilizer combinations applied. Zinc and iron were also applied at suitable rates, singly, in combination and as nil treatments. An application of a complete mixture of minor elements was confounded with the blocks.

This planting is not yet harvested but growth differences are evident. The most significant growth increase has occurred with nitrogenous fertilizer and the relationship between vegetative growth and nitrogen application appears to be practically linear. The phosphate effect is less spectacular but even the lowest phosphate treatment shows a visual improvement in growth when compared with nil phosphate.

The sub-plots without added nitrogen are showing premature flowering, dying of the basal leaves and premature maturity.

Leaf analyses are being carried out to study the N and P status in relation to the fertilizers applied.

It is premature to draw rigid conclusions from the trial but results indicate that soil exhaustion at Keravat is reached within five years under continuous sweet potato and after about the third year, yields decline rapidly. The maturation period of the crop appears to be closely correlated with the availability of nitrogen. Under Kervat conditions, it appears that there are three major problems in rationalizing shifting agriculture, namely the maintenance of fertility by the use of rotations and/or fertilizers, pest and disease control which may be a serious problem, and weed control, which is a much more serious problem in a stable form of agriculture than in a system based on shifting cultivation.

Three Course Rotation Trial.

Paralleling the soil exhaustion trial is a three course rotation trial comparing seven rotations based on subsistence crops and leguminous covers. There are three series or replications in time. The seven rotations are compared in each series but each is at a different stage. There are also three replications in space so that the trial comprises 63 plots. A plan of the trial is shown in Table 27.

As indicated in Table 27, the rotations vary from a narrow rotation (3 consecutive food crops, one of which is leguminous, repeated indefinitely) to a wide rotation (3 consecutive food crops followed by an equivalent period under a leguminous cover). Each rotation cycle takes approximately three years to complete.

The experiment is now nearing completion of the 2nd cycle and significant results are emerging. All rotations are giving decreased yields as the trial proceeds but the decrease is more rapid in the close rotations. At the third planting of the 2nd cycle when all plots of Series B were under sweet potato, the three wide rotations gave sweet potato yields averaging 8 tons per acre as against 5 tons for the narrow rotations. Peanut yields have likewise dropped from 5,500 lb. per acre to 4,700 lb. per acre in wide rotations and 2,700 lb. per acre in narrow rotations.

In the fifth planting of the 2nd cycle, which is growing currently, all plots of Series C are under sweet potato and there are marked visual differences in growth in the sweet potato in wide and narrow rotations. In the narrow rotations the crop is yellowing prematurely and the basal leaves are dying. Early flowering is also occurring and there are clear indications of premature maturity.

Terminal leaf chlorosis of varying intensity is present in the current planting of peanuts. Similar chlorosis has been observed in the leguminous covers and the symptoms appeared typical of either iron or manganese deficiency. This problem is at present under investigation in pot tests.

Pests and diseases have created serious problems in maintaining the experiment. All leguminous crops have suffered severe nematode attack which has been checked by soil injection of ethylene dibromide prior to planting. *Sclerotium rolfsii* wiped out the original peanut variety and the resistant variety, Schwarz 21, was substituted. Virus symptoms were also evident in peanuts. Taro tubers have been attacked by a scarab beetle and the leaves by a virus and by *Phytophthora colocasiae*. Sweet potato has suffered from aphid attack and virus disease, the latter necessitating a change of variety as in the soil exhaustion trial. Care with crop hygiene and constant treatment with insecticides have been necessary.

As in the soil exhaustion trial, intensity of cropping has resulted in severe pest and disease build-up even before soil deterioration would have forced an indigenous cultivator to move on to new land. It is too early to draw rigid conclusions, but it appears that 18 months of leguminous cover followed by 18 months food cropping is not a sufficiently wide rotation to maintain yields without the use of fertilizers. The narrow rotations have rapidly led to the development of symptoms resembling those shown in the soil exhaustion trial. At the completion of the second cycle, the results will be reviewed and the future of the trial determined.

TABLE 27.—THREE COURSE ROTATION EXPERIMENTAL DESIGN KERAVAT.

—	Block I.							Block II.							Block III.						
½ Year 1	SP	SP	SP	SP	SP	SP	SP	M	M	To	To	To	Pu	Pu	P+	P+	Ph	P−	P+	P+	P+
2	To	So	To	To	To	To	So	M	M	Ph	P−	P+	Pu	Pu	M	M	SP	SP	SP	Pu	Pu
3	P+	P+	Ph	P−	P+	P+	P+	SP	SP	SP	SP	SP	SP	SP	M	M	To	To	To	Pu	Pu
4	M	M	SP	SP	SP	Pu	Pu	To	So	To	To	To	To	So	M	M	Ph	P−	P+	Pu	Pu
5	M	M	To	To	To	Pu	Pu	P+	P+	Ph	P−	P+	P+	P+	SP	SP	SP	SP	SP	SP	SP
6	M	M	Ph	P−	P+	Pu	Pu	M	M	SP	SP	SP	Pu	Pu	To	So	To	To	To	To	So
Rotation No.	1	2	3	4	5	6	7	1	2	3	4	5	6	7	1	2	3	4	5	6	7
	Series A.							Series B.							Series C.						

Replicated 3 times in space.

M = *Mimosa invisa*. Pu = *Pueraria phaseoloides*. Ph = *Phaseolus calcaratus*. SP = Sweet potato (*Ipomoea batatas*). To = Taro (*Colocasia esculenta*). So = Sorghum (*Andropogon sorghum*). P+ = Peanuts (*Arachis hypogaea*) (trash returned). P− = Peanuts (trash removed).

HIGHLANDS AGRICULTURAL EXPERIMENT STATION, AIYURA.

The H.A.E.S., Aiyura, is the major high altitude experiment station in Papua-New Guinea. It is situated in the Eastern Highlands, basically at an altitude of about 5,200 feet, although the hills of the station rise to over 6,000 feet. The soil types range from silty peats of swamp origin to tropical red earths on the hills, often heavily laterized and shallow on the grassy hills, but free draining where forested. The annual rainfall is about 90 inches with a distinct though rarely severe dry season. The area has an even temperate climate with day maxima in the 70's and minimum temperatures usually in the range 45°–55° F. The total area is just over 2,000 acres, about half of which is flat (frequently swampy), or gently rolling and the remainder moderate to steep hills partly forested and partly grassland. The pattern of soils gives a good coverage of many of the main types found in large areas of the Highlands although it does not include the deep friable well-drained red earths which are amongst the most agriculturally valuable soils of the Highlands. A plan of the station is shown in Figure 10.

Aiyura is the major centre for investigations on Arabica coffee, pyrethrum and cinchona. Great emphasis was placed on cinchona production and research in the early post-war years but the development of better synthetics replacing quinine changed the situation and work is now confined to the maintenance of small stocks of superior genetic material. The station also conducts soil exhaustion and rotation experiments paralleling those at Keravat and has recently commenced work on air-cured tobacco and temperate climate vegetables. The entomologist to serve the Highlands area is located on the station but his work will be reported under the Entomological Section. A herd of cattle is also maintained.

The main work of the station will be reported on a crop basis.

Coffee (*Coffea arabica*).

The cultivation of *C. arabica* in the Highlands of New Guinea is almost entirely a post-war venture and coffee research dates only from about 1953 when serious commercial planting commenced. A wide range of experimental work covering all aspects of coffee production is under way at Aiyura. In addition to the major trials conducted there, there are also small scale trials at Goroka and Mount Hagen and on some individual planters' properties, as no one area in the Highlands is typical of all. The main lines of experimental work with coffee at Aiyura are as follows:

(i) The improvement of varieties by introduction, selection within existing varities, and hybridization followed by further selection. Techniques for the vegetative propagation of coffee by means of cuttings, budding and grafting have been worked out to test the value of selections.

(ii) Agronomic experiments covering such variables as species and density of shade trees, spacing of the coffee bushes, pruning systems, mulching, cultivation and the use of fertilizers.

(iii) Experiments in the use of different soil types, particularly with a view to finding ways of utilizing the lower grade and marginal soils; the use of fertilizers and different cultural practices are being investigated.

(iv) Processing of coffee is also under close investigation. The Department has demonstrated the use of caustic soda as an alternative to fermentation for demucilaging pulped coffee, and also mechanical demucilaging: it is planning a model factory to be built at Aiyura.

Linked to all trials is the assessment of quality. All selection work and experimental work on processing as well as fertilizer trials are closely tied to quality testing, which is carried out by co-operating firms in Australia and overseas. It has been demonstrated that the use of caustic soda for demucilaging has no adverse effect on quality.

Coffee Breeding.

Progeny Testing—Block E6.

The first approach in coffee breeding is the selection and testing of individual mother trees for genetical superiority. They are propagated vegetatively by means of cuttings or grafts and compared critically in statistically designed trials. The first series of 50 trees was propagated in 1957 and a second series in 1958. Progenies derived from self and open-pollinated seed obtained from each mother tree in the first series were also planted, to compare their performance with that of their clonally-propagated parents. In the second and future series, only open-pollinated progenies are being planted as the evidence to date is that all the Arabica strains in use are closely self-pollinated.

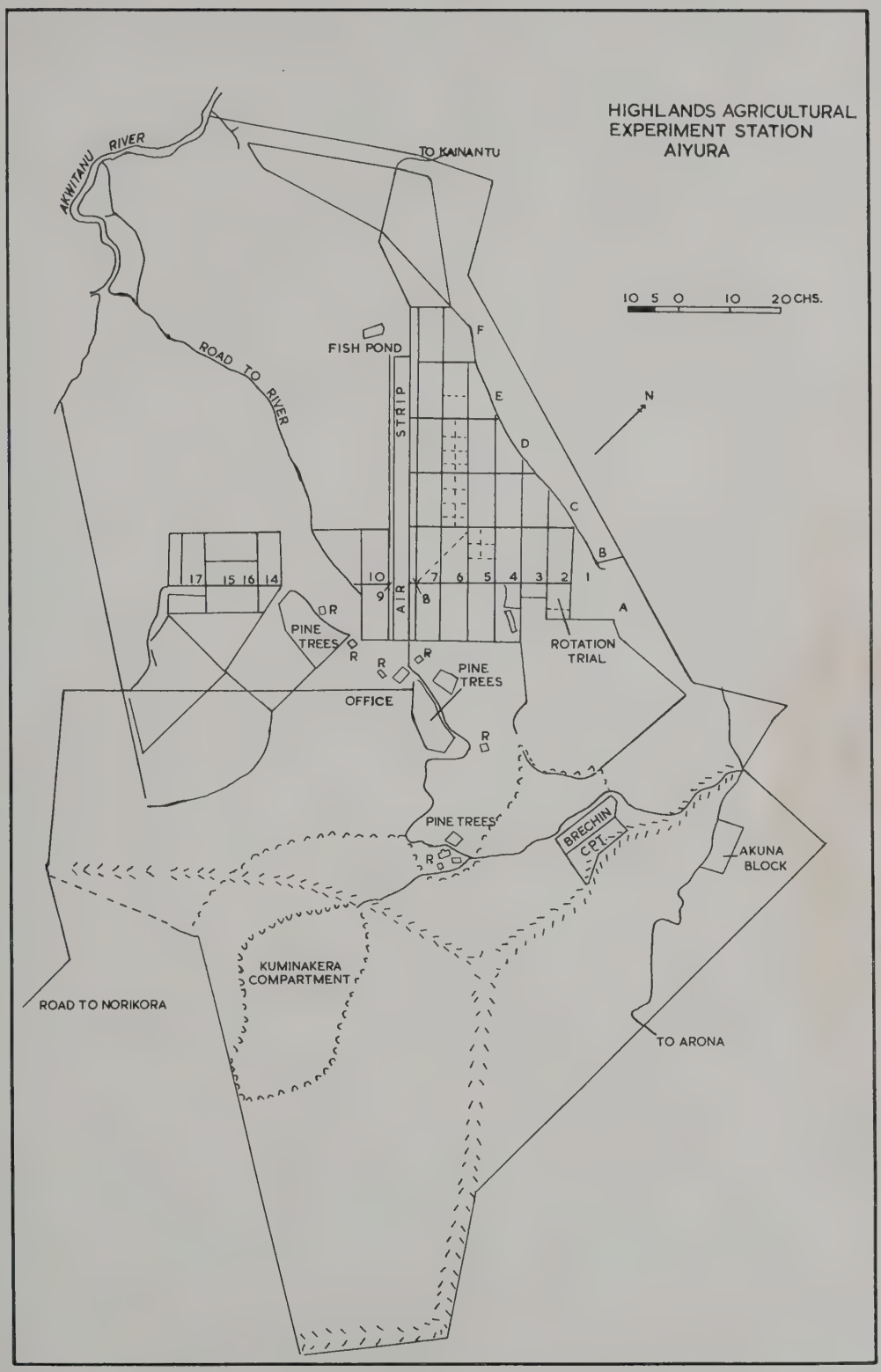

FIGURE 10—*Plan of the Highlands Agricultural Experiment Station, Aiyura.*

The results of the first year's heavy harvest indicated considerable differences between the progenies of selected trees. This may or may not be confirmed in the longer term. The general impression from the appearance of blocks of commercial coffee is that little advantage would accrue from single plant selection except for the exclusion of relatively rare off-types. In a closely self-pollinated crop not much improvement would be expected on theoretical grounds from single plant selection.

Coffee Introductions—Blocks A6, D5, E5.

Six new coffee varieties were introduced from East Africa in 1958 and after quarantine were planted out in a variety trial at Aiyura. The varieties " Blue Mountain " and " Bourbon ", which are the standard commercial varieties, were also incorporated for comparison. Similar but unreplicated variety plots of each type were also established at Goroka, Mount Hagen and Minj. The varieties are:

NG 4144	Dalle Mixed Green ..	ex Abyssinia during the war.
NG 4145	KE 20	An individual tree selection from French Mission trees at Upper Kiambu.
NG 4146	Kents ..	The original Kents from South India.
NG 4147	SL 14 ..	Selected from DR 11.
NG 4148	SL 28 ..	Selected from Tanganyika Drought Resistant.
NG 4149	SL 34 ..	Selected from French Mission trees at Kabete.

They are not yet in bearing.

Coffee Agronomy.

Shade Species x *Spacing* x *Pruning Trial—Blocks C6, D6, B15–16.*

This trial covers 20 acres, 10 acres being on " pit-pit " soil of high fertility and 10 acres on grassland foothills with laterization over portion of the block. The dominant natural swamp vegetation is " pit-pit " (*Saccharum*) and the soil is a silty peat overlying heavy clay. The trial is repeated on a small scale at Goroka and Mount Hagen. There are 4 replications on each soil type. The shade species are *Albizzia stipulata*, *Grevillea robusta* (silky oak), the local *Casuarina* sp., and a treatment with no permanent shade is included for comparison. The coffee variety is " Blue Mountain " and the spacings are 7 ft. x 7 ft., 8 ft. x 8 ft. and 9 ft. x 9 ft. on the triangle. Each plot is split into two pruning systems, namely single and multiple stem. The trial was planted early in 1956 and harvesting began in May, 1958. High yields are being recorded on Blocks C6 and D6 on the pit-pit soils and in the 12 months to the end of March, 1960, some plots at the closest spacing produced 1 ton of clean coffee per acre. At this early stage, long term trends cannot be predicted but, as would be expected, the yields at present show a high positive correlation with the number of bushes per acre. There is also a suggestion that no-shade is superior to shade in the Aiyura environment but little difference between prunings. *Grevillea robusta*, which is severely attacked by pests, is not growing satisfactorily but the other shade species are doing well.

Similar trends are emerging in the complementary trials at Goroka and Mount Hagen but at the former centre where rainfall is lower and sunlight higher, no-shade treatments are not yielding as well as shaded plots.

Variety x *Spacing Trial—Block B5.*

This trial was planted in 1956 at two spacings, namely 9 ft. x 9 ft. and 7 ft. 6 ins. x 7 ft. 6 ins. on the triangle. The five varieties are " Blue Mountain ", " Arusha ", " Mocha ", " San Ramon " and " Bourbon ". Because of a shortage of planting material, " Bourbon " was planted nine months later than the other varieties. Single stem pruning is used throughout with uniform *Albizzia stipulata* shade. " Mocha " and " Arusha " are performing better than either of the standard commercial varieties " Blue Mountain " and " Bourbon ", at this early stage. Similar results have been obtained in the complementary trials at Goroka and Mount Hagen.

Cultural Methods x *Spacing Trial—Block C3.*

This trial is concerned primarily with management and includes a spacing designed to allow for the use of mechanical equipment between rows, while at the same time giving the same number of trees per acre as the standard 9 x 9 spacing. The two spacings are 9 ft. x 9 ft. and 14 ft. x 5 ft. and the treatments at each spacing are clean weeding, mulching, and covers with *Indigofera endecaphylla* and *Vigna oligosperma*. There are four replications.

The plots with either cover are much less thrifty than clean weeded and mulched plots, and the heights of the coffee trees in the former are uniformly less. To minimize the heavy competitive effect of the covers, they have been pulled back for a couple of feet on either side of the coffee bushes. With the 14 ft. x 5 ft. spacing, it is planned that mechanical equipment will be used for weeding when the temporary shade is removed to allow passage of implements.

The early yields show a clear advantage for clean weeding and mulching over the cover crop treatments. However, the cover crops do minimize maintenance and in the future attempts will be made to see whether the competitive effect of the covers can be reduced by fertilizing.

Variety x *Spacing* x *Pruning Trial—Block B*14.

This trial is planted on poor, lateritic hillside soils partly to test the alleged drought resistance and hardiness of the varieties " Arusha " and " San Ramon ". " Blue Mountain " and " Bourbon " are included for comparison. The three spacings for " Blue Mountain ", " Arusha " and " Bourbon " are 9 ft. x 9 ft., 8 ft. x 6 ft. and 9 ft. x 4 ft. 6 ins. " San Ramon ", which has a more dwarfed habit, is planted at 8 ft. x 6 ft., 9 ft. x 4 ft. 6 ins. and 5 ft x 5 ft. Two pruning systems are used—East African multiple stem and Hawaiian multiple stem. The coffee was planted in January 1959 with *A.stipulata* shade. At this stage, " Arusha " and " San Ramon " are well ahead in growth with " Blue Mountain " having progressed least. This is particularly noticeable on the shallower soil of the upper part of the block.

*Pruning Trials—Block A*10 *and Akuna Road.*

The Akuna Road trial is an observational trial on multiple stem coffee which has been capped at 6 feet. This is a common practice in the Highlands although not a standard pruning method and likely to lead to difficulties in bringing in a new cycle. In all standard multiple stem systems, the uprights are left uncapped. Six treatments are being used including a no-pruning treatment and observation will be centred on how best to bring in a new cycle and convert to standard multiple stem pruning.

The trial in A10 is a formal trial on single stem coffee, designed to test the long term effect of varying intensities of pruning. The treatments are:

(i) Unpruned except for removal of upright water shoots and cleaning out of centre of the bush, which treatment is included in all other treatments.

(ii) Head primaries only (top four pairs) cut back to new shoot growth. This keeps an abundance of fresh growth at the top of the bush and requires little skill.

(iii) Light pruning following standard single stem practice. All secondaries and tertiaries in excess of two at each node are removed. All ingrowing secondaries are removed.

(iv) Heavy pruning. All secondaries and tertiaries in excess of one at each node are removed.

(v) Pruning confined to thinning out of the primaries, especially the lower primaries which trail on the ground.

Results for the year ending 31st March, 1960, were as follows:

TABLE 28.—YIELDS OF CLEAN COFFEE PER ACRE (IN LB.).

BLOCK A10, PRUNING TRIAL.

No pruning	1,593
Head primaries pruned	1,637
Light pruning	1,287
Heavy pruning	1,158
Primaries thinned	1,301

Fertilizer Trials.

Fertilizer trials of various kinds are conducted at Aiyura on the poorer soils, especially on laterized soils. Chemical analyses and impeded coffee growth suggest deficiencies as a limiting factor. Diagnostic trials are therefore being conducted.

There is great interest in the Highlands in fertilizing for higher production even where obvious deficiencies do not occur. High level fertilizer trials have therefore been laid down in an attempt to determine the most economic rates and mixtures to be used for maximum production on average and good coffee soils. The soil types used in this trial at Aiyura are fair grassland soils and good pit-pit soils. Similar trials at Goroka are laid down on first class, deep, red-earths and at Mount Hagen on deep pit-pit soils.

*Factorial Fertilizer Trials—Blocks B*15–16 *and E*7.—Block B15–16 is a laterized hillside soil and E7 contains partly pit-pit soils and partly grassland soils; this trial is on the grassland type. It is a diagnostic trial using both major and minor elements and is factorial in design.

Practically all treated plots, irrespective of the mixture of elements used, are better than untreated plots. Those few treatments which are little if any better than no fertilizer involve KCl or $CaCO_3$ singly or together; all other factorial combinations include sulphates. Those plots not receiving sulphates show the poor development and chlorosis typical of the unfertilized plots, which suggests that sulphur may be the deficiency. This will be checked in pot trials and by means of field trials comparing the effects of urea and sulphate of ammonia at rates giving an equivalent amount of nitrogen and similarly with calcium carbonate and calcium sulphate at rates giving equivalent amounts of calcium. Fertilizer was applied first in 1957 and repeated in 1959.

*Omission Method Fertilizer Trials—Blocks A*15–16 *and E*7.—Paralleling the factorial fertilizer trials are additional diagnostic trials using the omission method. Harvesting began in January, 1959, but no trends have yet shown up in this trial.

*High Level Fertilizer Trials—Block E*7.—Block E7 consists of two soil types—pit-pit soils and poorer grassland soils. Duplicate high level fertilizer trials have been put out on the two soil types and similar trials are being conducted on good coffee soils at Goroka and Mount Hagen. Two levels of nitrogen, two levels of phosphorus and two or three levels of potash are used, with or without minor elements. The design is factorial and the highest level is about 1 ton of complete fertilizer per acre. The first application was made in November, 1958.

Yields have been very heavy on all soil types and in some plots have exceeded 25 cwt. per acre of clean coffee. Apart from a tendency for the unfertilized plots to fall behind the fertilized plots, especially on the poorer soils, no trends are yet evident. Table 29 shows typical results.

TABLE 29.—YIELDS OF CLEAN COFFEE (LB.) IN HIGH LEVEL FERTILIZER TRIALS, AIYURA, FOR YEAR ENDING 31ST MARCH, 1959.

Treatment.	Block A Grassland Soil.	Block B Pit-pit Soil.
	lb.	lb.
N1P1K1 plus minors	2,045	2,616
N1P1K2 plus minors	2,030	2,842
N2P1K1 plus minors	2,661	2,774
N2P1K2 plus minors	1,984	2,849
N1P2K1 plus minors	2,165	1,940
N1P2K2 plus minors	2,849	2,023
N2P2K1 plus minors	1,353	3,127
N2P2K2 plus minors	3,037	1,849
N2P2K2 less minors	2,233	2,059
N2P2K2 less minors	2,360	2,526
Nil	1,466	2,345
Nil	1,330	2,300

Pyrethrum.

Pyrethrum seed was introduced to Aiyura a number of years ago but the first strains brought in, having come from non-tropical regions, did not flower satisfactorily. In more recent years, strains from several tropical countries have shown promise. All introductions have been made as seed and selections carried out in the progenies for the following characteristics:

(i) Erectness of flower stems.
(ii) Regularity of flowering.
(iii) Prolific flowering habit.
(iv) Largeness of flowers.
(v) Flowering habit persisting into the second and third years of growth.
(vi) Pest and disease resistance leading to the persistence of the strain in the field.

Strains so selected have been subject to chemical analysis of the pyrethrins content. About 30 clones have reached the required standard and further selection is continuously adding to the list.

Plate 9 shows the flowering habit of a good selection, and Plate 10, the variation in flowering habit between strains.

Isolated biclonal and polyclonal seed gardens are being established at Aiyura and other suitable centres throughout the Highlands, covering a range of altitudes and rainfalls. These gardens will serve a dual purpose of supplying seed for commercial planting and testing the effects of different environments on flowering and pyrethrins content.

Soil Exhaustion and Rotation Trials.

Soil exhaustion and rotation trials have been established at Aiyura using designs identical with those at Keravat but with the crop and leguminous cover species adjusted to suit the different climatic conditions. One cycle of 6 crops has been completed but the results are not yet analyzed.

AGRICULTURAL EXPERIMENT STATION, EPO.

The Agricultural Experiment Station, Epo, is situated on a flood plain only a few feet above sea level about 70 miles north-west of Port Moresby. It lies in the rain shadow zone with an average rainfall of 52 inches per annum over the last decade. Rainfall is strongly seasonally distributed and there is a typical lowland temperature range. The station comprises about 1,200 acres of grass covered alluvial plains with belts of timber. The soils are deep clay-loams of high fertility and subject to irregular seasonal inundation. The whole area is unstable and the rivers frequently change course.

The Station was first established in the post-war period, primarily as a centre for investigation of upland rice growing and for encouraging the production of this crop on a scale which would exceed the subsistence needs of the people. Neither the scheme nor the Station has been very successful. It is now apparent that the location of the Station is not ideal and the rainfall is lower and less regular than appeared in its early years. For this reason, the emphasis has swung away from upland rice work and except for pure seed production, the main work with this crop in the future will be the investigation of flooded rice production with pumped water. At the same time, a wide range of crops is under study, particularly annual crops, together with the development of a system of land use patterns including cattle grazing. In line with experience elsewhere in the world, weed control is a major problem in annual crops and a serious impediment to upland rice production on a continuing basis. The main trials during 1959–60 were as follows:

Rice Breeding and Agronomy.

Except for the maintenance of genetic stocks and pure seed production, much of the work with rice is now done off the station in districts more adapted to upland rice culture. However, some breeding work is still in progress on the station.

Indica-japonica Hybrids.

Crossed seed of several Indica-japonica hybrids was made available in 1955 through the courtesy of the International Rice Commission. A list is shown in Table 30.

TABLE 30.—INDICA-JAPONICA HYBRIDS.

Introduction Reference No.	Cross.
N.G. 3673	Fukoku x Sagumpal
N.G. 3674	Fukoku x Concejela
N.G. 3675	Fukoku x Palwan
N.G. 3676	Zuihuo x Dj Mudtair
N.G. 3677	Zuihuo x Dj Intan
N.G. 3678	Zuihuo x Sagumpal
N.G. 3679	Zuihuo x Radin China
N.G. 3680	Zuihuo x Myang Subtil
N.G. 3681	Zuihuo x Reyonc 6
N.G. 3682	Zuihuo x Concejela

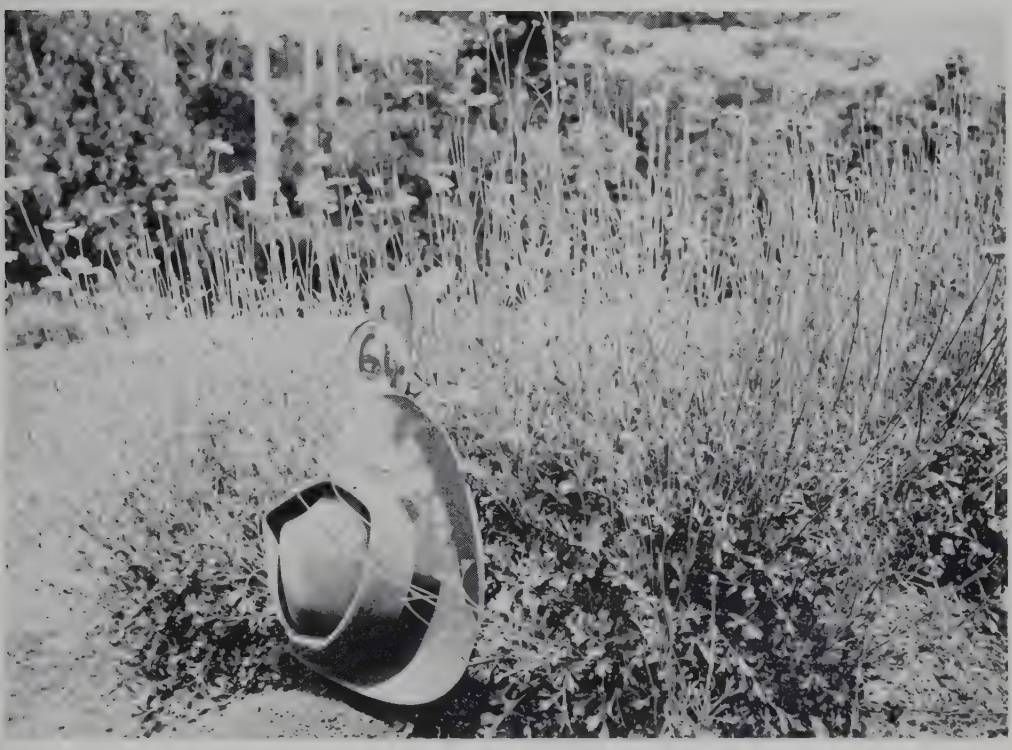

PLATE 9—*A desirable Pyrethrum strain, free flowering and with erect habit.*
[Photograph J. Stackhouse]

PLATE 10—*There is considerable variation in habit and productivity between strains of Pyrethrum.*
[Photograph J. Stackhouse]

It was planted in quarantine and initial selections made before being sent down to Epo for observation and selection in subsequent seasons. Throughout the period of selection, there has been a conscious bias towards types with japonica-type grain. This has been done in order to avoid losing the desirable japonica character of short stiff straw; indica characters tend to predominate in the crosses. Wherever upland rice has been grown in the Territory, the straw of indica types has been too flaggy and shorter straw is one of the most valuable characteristics sought from these hybrids. A number of selections look potentially valuable and the F6 planted in 1959–60 appeared to be uniform with little further segregation. Unfortunately the performance of selections was poor owing to the adverse season and no further selection could be carried out. The selections will be kept under observation and seed increased in 1960–61 and it is hoped to put them into field trials in 1961–62.

Other Crosses.

In 1952 a number of crosses was made between strains which had shown promise locally. By 1959–60 selections had ceased segregating to any degree and were planted for seed increase prior to field trial. Unfortunately they suffered the same setback as the Indica-japonica hybrids and seed increase was inadequate so that the programme of field trial is set back one year.

Introductions.

Eight varieties of rice from the Philippines were received from quarantine and sown for observation. The varieties are shown in Table 31.

TABLE 31.—RICE INTRODUCTIONS FROM PHILIPPINES.

Introduction Reference No.	Variety Name.
N.G. 4062	Elonselom
N.G. 4063	Wag Wag
N.G. 4064	Vincer
N.G. 4066	Fa Yin Tsai
N.G. 4067	Leune Cho Kuik
N.G. 4068	Wong Hok Chai Mei
N.G. 4069	Fall Crop Sz Mei
N.G. 4070	Lo Shui Nga

Again these introductions performed poorly because of the adverse season and no selection was carried out within the lines. However, they appeared to be very pure. They will receive further trial in the coming season.

Variety Trials.

During the 1958–59 season, unreplicated observation plots were planted at 29 centres throughout the Territory in order to determine the suitability of different varieties to the various environments. The plots contained 14 varieties showing the most promise at Epo and it is interesting to note that although conditions at Epo are not typical of the environment of good rice growing areas, varieties which showed promise at Epo did well elsewhere. In the 1959–60 season, the initial observation plots were followed up with a series of replicated variety trials conducted at eleven centres throughout the rice growing regions of the Territory. Results from these trials are not yet available.

Pests and Diseases.

All rice plots were attacked by the insect *Leptocoryza varicornis* but damage was severe only in the latest maturing crops. Control with dieldrin spraying was attempted in some heavily infested experimental plots. The bulk crop was heavily infested with stem borer (*Diachraea* spp.); stem borer infestation was light on the more widely spaced experimental plots. On the other hand, pyraustid leafroller, noted on the experimental plots, did not appear on bulk rice.

The bulk crop had slight infections of *Helminthosporium oryzae* and *Ramularia* sp. Again experimental plots were more heavily infected.

Abaca (Manila Hemp) (*Musa textilis*).

The banana is a food crop of major importance in the area which suggests that *Musa textilis* might also perform well. A small observation plot using material obtained from Keravat was planted in 1958 but was destroyed by flooding. In 1959–60 a clone x spacing trial was planted in a randomized block, with 6 clones, 3 spacings, 4 replications and 25 plants per plot, on land above flood level. The clones are K6, K7, K9, K22, KT6 and KT13. The spacings are 10 ft. x 10 ft., 12 ft. x 12 ft. and 14 ft. x 14 ft. The rather wide spacings are based on Keravat experience. Establishment was only fair but the missing plants will be made up in the coming wet season.

Cashew Nut (*Anacardium occidentale*).

Three hundred seeds of cashew nut from India were planted in May 1959; 93 per cent. germination was obtained in four weeks but subsequent flooding reduced the number of seedlings established to 90. These have virtually all survived and are growing well. They will be retained for observation and possible selection. The environment is very suitable for cashew nut production in those areas which are flood free.

Cotton (*Gossypium hirsutum*).

In May 1959, six cotton varieties were obtained from the Queensland Cotton Board and planted at 3 ft. 6 ins. x 2 ft. spacings for observation and preliminary yield assessment. The varieties were—Miller, Lankhart 57, Empire, Bobshaw 1A, Mexicala Res., and D. and P.L.15. Although the plots suffered initially from water-logging and later from water strain, as they were deliberately planted to mature in the dry season and no additional water was given, and there was also fungal and insect damage, yet they produced yields ranging from 400 to 1,200 lbs. of seed cotton per acre. In view of the encouraging initial experience, the same varieties were incorporated in a replicated time of sowing x spacing x variety trial at Epo and in the Markham Valley in 1959–60.

These trials are not yet harvested. They incorporate the six varieties, three spacings, three times of sowing and three replicates in a plaid design with spacing in columns. Each plot consists of four rows 50 feet long, the central two rows to be harvested for yield purposes. The spacings are 3 ft. 6 ins. x 1 ft., 4 ft. x 1 ft. and 4 ft. 6 ins. x 1 ft. 6 ins. Sowing dates at Epo were 10th March, 1960, 20th April, 1960 and 12th May, 1960. The trial has been sprayed regularly with 0.05 per cent. Dieldrin to control leaf eaters, stem borers and boll weevils.

Six additional varieties from the United States of America have been introduced for observation.

Castor Bean (*Ricinus communis*).

Previous work with this crop consisted of variety and spacing trials conducted in 1951–53 using both tall and dwarf varieties. The former are suited to hand cultivation and the latter to mechanized culture.

The castor bean has proved unsuitable for wet season cultivation because of heavy insect damage which is difficult to control. As a dry season crop, however, it grows very well at Epo and is able to germinate in a dry seed bed. It is also a simple matter to store seed, which is not attacked by insects and does not deteriorate noticeably.

Although the tall varieties could find a place in native agriculture, large scale production requires indehiscent dwarf varieties high in yield and with seeds of uniform size, high oil content and thin, easily-removed hulls. During 1959–60, six phenotypes were selected from the mixed population growing as weeds on Epo and planted in a spacing x variety trial. The seed was so mixed that the trial was abandoned. The station is now holding sixteen varieties from Ceylon, South Africa, France and Australia and these will be planted for observation and multiplication preparatory to a programme of selection.

Coffee (*Coffea canephora*).

Five acres of Besoeki robusta coffee were planted out in April, 1960 under *Crotalaria anagyroides* and *Leucaena glauca* shade. A further area has been prepared for planting a polyclonal seed garden using Keravat selections.

Maize (*Zea mays*).

Maize in the Territory is badly affected by African maize rust (*Puccinia polysora*). Three resistant introductions from East Africa are being tested for resistance to local strains of the fungus and for agronomic characters, to determine whether they are suitable for direct use. They were grown adjacent to local varieties heavily infected with rust and their performance is shown in Table 32.

TABLE 32.—RESISTANCE OF INTRODUCED MAIZE VARIETIES TO *PUCCINIA POLYSORA*.

Variety.	Number of Plants.	Per cent. Infected.*	Per cent. Susceptible.
Tanag No. 1 White Dent	336	4.5	Nil
Tanag No. 1 White Flint	742	3.3	Nil
Improved Katumbili	206	4.0	Nil

* With non-sporulating lesions only.

All three maintained their resistance to the strain or strains of *P. polysora* occurring in the area. The three varieties were also scored for aphid and powdery mildew attack and the results are shown in Table 33.

Table 33.—APHID AND POWDERY MILDEW ATTACK ON INTRODUCED MAIZE VARIETIES.

Variety.	Number of Plants.	Per cent. Aphid infested.	Per cent. Powdery mildew.
Tanag No. 1 White Dent	336	7.7	8.5
Tanag No. 1 White Flint	742	3.3	4.0
Improved Katumbili	206	6.0	7.5

Inflorescences of each variety were bagged and hand pollination effected using only those plants free from rust, mildew infection and aphid attack. Yield trials will be conducted in 1960–61 using these and local varieties.

Oil Palm (*Elaeis guineensis*).

It is well known that the oil palm is capable of much higher yields of oil per acre than the coconut, but for various reasons it has been largely neglected in the Territory. Genetic stocks have recently been imported from Malaya and are planted out in a nursery at Epo. The Dumpy mutant, which is a *dura* type, with normal yield but only about two-thirds normal stature, is included, as well as material which should yield *dura*, *tenera* and *pisifera* characters.

Peanut (*Arachis hypogaea*).

During the period 1951–54, trials were conducted to determine the reactions of the varieties Red Spanish and Virginia Bunch to different spacings, times of sowing and fertilizer treatments. Neither variety responded to fertilizer treatment in any year but time of sowing had a very significant effect, the best time being early to mid-wet season so that the crop matured as the dry season was coming in. Virginia Bunch yielded well at spacings of 30 inches x 9 inches to 36 inches x 6 inches and Red Spanish was most successful at 24 inches x 9 inches in two years out of three.

Approximately 60 recently introduced varieties were planted towards the end of the year for observation prior to variety testing and seed production. The plots are replicated for the purpose of gaining preliminary yield data and have been inspected regularly for fungal, insect and rodent damage. No serious damage has yet occurred but the plots, which went in rather late, have suffered from lack of water.

Sisal (*Agave sisalana*).

Two hundred sisal bulbils have been established in a nursery for transplanting to the field.

Pasture Species.

Grasses of the genera *Eleusine*, *Chloris*, *Panicum*, *Cenchrus*, *Andropogon*, *Ischaemum* and *Dicanthium* have been sown for observation. A wide range of legumes has also been sown for observation with regard to their possibilities as shade, smother and green manure crops and pasture species.

RUBBER SECTION, BISIANUMU.

Bisianumu is situated about 30 miles from Port Moresby, 1,500 feet above sea level, in the heart of the most important rubber growing area in Papua. The rainfall is about 100 inches per annum with marked wet and dry seasons although in most years rainfall does not fall below 2 inches in any month. The temperatures are almost as high as on the coast during the day but night temperatures are lower. The Rubber Section is part of a large livestock station, about 300 acres being set aside for rubber work. One hundred acres is carrying mature (twenty-year old) seedling rubber. The soils are chocolate clay loams overlying yellowish clay sub-soils formed *in situ* from volcanic agglomerate. The topography is rolling to rough with a natural rain forest cover. Part of the area has long been cleared and part is still under rain forest, being cleared only as required for planting.

All rubber investigations for the Territory are carried out at Bisianumu. There has been no hybridization or selection as such and effort has been concentrated on the introduction, multiplication and distribution of the leading clones available overseas. A very good world collection of clones is now held, many of them being proprietary and distributed under licence. Clonal trials are being carried out to test the relative value of imported clones under local conditions and a clonal seed garden has been established to produce seed for local use. In addition, trials with yield stimulants are being carried out on the mature seedling rubber. The main investigations are as follows:

Budwood Nurseries.

Imported clones are held in permanent budwood nurseries. During the year, three new clones were imported, bringing the total number to 58, including two clones selected by Papuan planters. The budwood nurseries were established during 1955–56, the principal aim being to produce sufficient budwood for the establishment of a clonal seed garden and clonal yield trials. As the budwood was multiplied and agreements on its distribution finalized, it became available for sale to planters and, since January, 1958, production of budwood for sale has been the principal purpose of the budwood nurseries. Sales have increased from 50 yards in 1957–58 and 233 yards in 1958–59 to 528 yards in the current year. To meet anticipated demand for the most promising clones, new multiplication plots were established during the year. Plate 11 illustrates a budwood nursery.

Museum Plots.

These plots consist of clones which are no longer considered to be of the first rank. They are mainly older clones which have been outclassed by the modern clones and are not considered worth testing in formal clonal yield trials. Nevertheless it will be interesting to observe their behaviour under local conditions and some of them may have value for future breeding programmes. The clones are being tested in unreplicated plots of 60 trees which will permit a reasonable assessment of their value. There are 24 such clones planted on the contour and now in their fourth and fifth year since budgrafting.

In April, 1960 a mysterious dieback disease occurred, a total of 24 trees being seriously affected. It is thought that the condition was caused by lightning strike. Except for these occurrences, the growth of all trees is satisfactory, although naturally better on the lower slopes than on the somewhat eroded tops of the hills.

Clonal Seed Garden.

A clonal seed garden of 40 acres was established in 1958–59 with the objective of producing high yielding seed for distribution to Territory rubber planters. The first yield is expected in 1964. There are five clones, namely:

A	Tjir 1
B	AVROS 157
D	RRIM 501
D	PR 107
E	BR 2

The lay-out is in single avenues of each clone in the following arrangement:

AAAAAA
BBBBBB
CCCCCC
DDDDDD
EEEEEE
BBBBBB
DDDDDD
AAAAAA
CCCCCC
EEEEEE

PLATE 11—*The best quality rubber budwood is grown in a specially-prepared nursery.*
[Photograph J. Warr]

PLATE 12A. PLATE 12B.
Skilled Papuans carry out all operations in rubber budgrafting.
[Photograph J. Warr]

This basic unit is repeated four times with an additional final row of Tjir 1. The rows are 30 feet apart with 10 feet between the trees, i.e., 145 trees per acre, eventually to be thinned to 100 trees per acre. This spatial arrangement gives each clone an equal possibility of being cross-pollinated by every other clone in the garden. The inner seed garden is of 12 acres, the surround being designed as a buffer zone to prevent chance cross-pollination from clones outside the garden.

During the year, replants were made as necessary. Growth is generally satisfactory except in one rather eroded corner.

Clonal Yield Trials.

First Clonal Yield Trial.

There are twelve clones in the trial with 200 trees per clone in four replications of 50 trees per plot, spacing 30 feet x 8 feet. Thinning will later be carried out. Three replications of the trial were planted with budded stumps in March, 1959, and the fourth replication was planted with stumped buddings in March, 1960. Growth is generally good.

Second Clonal Yield Trial.

This trial also comprises twelve clones, one of which is common to all clonal trials to give a basis for comparison. There are 240 trees per clone in four replications of 60 trees per plot with spacing at 30 feet x 8 feet. Three replications were planted during March, 1960, as budded stumps, and the fourth replication will be planted with stumped buddings next season. Losses in transplanting of budded stumps were less than 1 per cent. and it is thought that spraying of the stumps before transplanting with Ceremul M was an important factor contributing to this result.

Third Clonal Yield Trial.

It is planned that this trial will include eight clones, one of which will again be common to all clonal yield trials, with 200 trees per clone in four replications of 50 trees per plot and again with spacing 30 feet x 8 feet, in common with the other trials. However, this is to be budded in the field. Seedling stock was planted in April, 1959. In half the trial, growth is most satisfactory but unfortunately in the other half, the seedling stocks are retarded because of the relatively poor growing conditions prevailing there. It is most difficult in this hilly and rather erodible country to find plots of uniform fertility.

Yield Stimulant Trials.

There is a major stimulant trial to test the use of 2, 4, 5–T and 2, 4–D stimulants, applied at varying intervals of time on different sections of the tapping panel and with varying intensities of tapping. The treatments correspond fairly closely to the types of treatment under test in Malaya and the main aim of the experiment is to determine how closely Malayan experience may be applied in Papua. The trial commenced in July, 1958 and figures to date indicate that results will closely paralled those obtained in Malaya although there is some suggestion that slaughter tapping combined with heavy stimulation may be less damaging in Papua than in Malaya, possibly because of the rather higher fertility status of most Papuan rubber-growing soils.

A second small trial commenced in May, 1959 is designed to test the claims of the manufacturers that a 2, 4, 5–T based stimulant known as " Ready Rub " is as effective as a standard 2, 4, 5–T based stimulant, without the necessity to scrape the rough bark before application. Should this contention be proved, it would save considerable expense and trouble in the application of stimulants. The trial has not yet continued for a sufficient period to enable a final analysis of results to be made. However, it is obvious that stimulation with both treatments is immediate and continues for about the same period.

Nurseries.

Nurseries were planted during the year on a sufficient scale to ensure the production of adequate stocks for future trials.

Budgrafting Course.

Since the sale of budwood began, the Station has conducted courses in budgrafting for indigenous workers. Interest has been rising and nineteen trainees from nine different plantations successfully completed a six weeks' training course, commenced in October, 1959. The use of budgrafted material is a relatively new concept to local planters and the provision of a training course for budgrafters has greatly stimulated the demand for budwood. A Native budgrafter is shown at work in Plates 12*a* and 12*b*.

PLANT INDUSTRY CENTRE, BUBIA.

Bubia is situated in the Lower Markham Valley 9 miles from Lae, a few feet above sea level. The area is 530 acres and the rainfall approximately 110 in., seasonally distributed, although months with less than 4 in. of rain are rare. The soils are mainly alluvial and colluvial flats although the back of the Station runs up to hills of marine alluvial origin. The Valley soils are base saturated with a pH usually not far below neutrality at the surface and increasing rapidly with depth to values which may exceed 8 at 2 feet to 3 feet. The Station is reasonably typical of the lower Valley. There is great variation in rainfall throughout the Valley ranging from 180 in. at Lae to about 50 in. near Erap in the centre of the Valley. There is also considerable soil variation; although the soils are all alluvial or colluvial and typically base-saturated, they range from stony plains with practically no top soil to deep alluvials of medium to heavy texture.

The Station staff includes one Agronomist whose duties cover trials located off the Station as well as trials on Bubia and an Entomologist who serves the New Guinea mainland.

The main agronomic work in the past has been concentrated on sisal and other hard fibres and work is also being carried out on cacao, coffee, cotton, peanuts, vanilla and other crops. The principal investigations currently in progress are as follows:

Sisal (*Agave sisalana*).

Over the past five or six years, there has been a considerable amount of work carried out with sisal, particularly with regard to planting methods, productivity, harvesting, processing and packaging. All investigations were carried out on a clone introduced to Papua about fifty years ago. Also maintained at Bubia are sisal clones from Tanganyika, Queensland and Indonesia and a clone of the related *Agave amaniensis*, introduced to the Territory before the war.

Following successful tests on the fibre produced at Bubia, prospects for commercial production have been investigated in the drier parts of the Markham Valley and other parts of the Territory. However, interest in the crop has declined since the visit of an expert from Tanganyika who considered that " ecologically and economically Papua and New Guinea are not sisal countries ". Since the visit of this authority, activity with sisal has been confined mainly to planting blocks in different environments to test his contention that these areas are ecologically unsuited to sisal. Plots have been established near Popondetta in Northern Papua and at Sangan, Marilumi and Erap, all in the Markham Valley. These blocks will serve not only for observation but also as a source of planting material should there be any further interest in sisal production in Papua-New Guinea.

Peanuts.

Some 64 peanut varieties were multiplied during the year for comparison with the two varieties at present being grown in the Markham Valley, namely Virginia Bunch and White Spanish; commercial peanut production has increased in the drier parts of the Valley and currently exceeds 1,000 tons per annum with potential for further expansion.

These are the same varieties as are under trial at Epo. None of the varieties under test had any obvious advantage over the White Spanish variety which is grown almost exclusively in the Valley. It is well suited to the local environment and also markets well.

Cotton.

The soils and climate of the drier parts of the Markham Valley are such that cotton growing may have commercial possibilities. Accordingly a variety x spacing x time of sowing trial has been laid down at Erap using the same varieties and experimental design as at Epo. The times of sowing were 14th March, 28th March and 13th April, 1960, i.e., in the latter part of the wet season so that the crop would mature in the dry season. Growth has been excellent but insect damage severe, the most important pests being an unidentified stem borer and a boll worm (*Heliothis* sp.). Endrin has been the most effective insecticide as an 0.05 per cent. spray and a 0.75 per cent. dust. DDT was less effective and did not control the stem borer. A tractor-operated power spray was suitable until the plants became too tall. The " Fontan " power driven portable duster was found to be effective as the bushes became denser.

Cacao.

There has been appreciable commercial cacao planting in the Lower Markham Valley in the post-war period. However, after a good early start and frequently one or two heavy crops, most of the cacao shows an unthriftiness which develops to a dieback condition, ultimately causing the death of the tree. The fungus *Botryodiplodia theobromae* is invariably associated with the condition but pathological investigations suggest that it is not the primary

cause. Insect pests, especially mealy bugs, are also severe and may have a role in the complex. The high pH of sub-soils particularly is not likely to be favourable to cacao and there are indications of a deficiency of available minor elements, especially zinc. Leaf symptoms of zinc deficiency are readily found and a response is given to spraying with zinc, but this does not alleviate the dieback condition appreciably.

A series of trials is in progress covering pathological, entomological and nutritional factors. Treatments are being applied to affected mature cacao in an effort to alleviate the condition and rehabilitate the stand, and to newly-established seedling cacao to determine whether the onset of the condition can be prevented.

Coffee (*Coffea canephora*).

Work with coffee is confined to the maintenance of stocks for seed production. Coffee is generally healthy except for leaf symptoms of minor element deficiencies which are relieved by appropriate spraying.

Vanilla (*Vanilla planifolia*).

A single clone of vanilla was introduced some years ago and has been grown on living *Leucaena glauca* trees. The vines flowered heavily from November, 1959, to January, 1960, and many pods were produced by hand-pollination. Beans were successfully processed after killing either with hot water or refrigeration. Further investigations will be made on the cultivation and processing of the crop.

Pasture Species.

There are considerable areas in the Markham Valley potentially suitable for beef cattle production and some settlers are already established. The natural grasslands carrying mainly kunai (*Imperata* sp.) on the better soils and kangaroo grass (*Themeda* sp.) on the poorer soils are poor in nutritional value and low in carrying capacity. Grasses and legumes are being established on Bubia in observation plots and will be tried on a larger scale at Erap. Elephant grass (*Pennisetum purpureum*), Guinea grass (*Panicum maximum*), Para grass (*Brachiaria mutica*) and Buffel grass (*Cenchrus ciliaris*) are already established in parts of the Valley and Pangola grass (*Digitaria decumbens*) is the most promising recent introduction. Three introduced strains of *Leucaena glauca* from El Salvador, Guatemala and Peru have greater vigour than the local strain and this, together with their reputed lower mimosine content, makes them promising as forage legumes.

EXPERIMENTAL TEA PLANTATION, GARAINA.

Garaina is not strictly an experiment station as there is little experimental work in progress but it is a pilot commercial tea plantation, planted to assess the problems of tea growing and the economics of tea production in Papua and New Guinea. At present there is no established commercial tea production in the Territory although desultory attempts have been made to commence such operations on a small scale in the post-war period.

Garaina is situated in the Waria Valley at an altitude of little over 2,000 feet, on the valley floor. The whole area is flat with a tendency to swampiness and is in fact an old lake bed. Rainfall is about 110 inches per annum, seasonally distributed, but with no month averaging less than 3 inches. The temperatures are equable, usually ranging between 70–80° F. in the day and falling to the 50's at night. The soils are sandy clays developed on old lacustrine deposits and are very acid with low base status.

Planting commenced in 1949 using imported seed from Assam and from South Johnstone in Queensland. The South Johnstone material is also an Assam djat. At a later date a Malayan djat was imported. The original importation served to establish a 20-acre seed garden and a small plucking area only. Little further planting took place until 1954 when large quantities of seed became available from the seed garden. Between 1954 and 1957, 80 to 100 acres of tea were planted annually and the total plucking area is now 350 acres. Double hedge systems were followed throughout except for 30 acres where a range of experimental spacings has been used.

Almost the whole of the planted area is now ready for plucking and the erection of a factory for processing the produce commenced shortly before the end of the report year.

Activities during the year were generally confined to maintenance. The last-planted 120 acres were centred to 6 inches preparatory to establishing a plucking table. Ninety acres were pruned back and misses supplied in the centred and pruned areas.

Most of the tea was originally planted without shade and in some areas the shade species failed. *Grevillia robusta*, *Gliricidia maculata* and *Erythrina* sp. all failed but *Albizzia stipulata* is now established in all but 80 acres.

Additional nurseries were established during the year for supplying and also to fill any small areas not previously planted for various reasons such as poor local drainage.

Mealy bug attack on *Albizzia stipulata* has almost disappeared following the introduction of stocks of the Ladybird predator, *Cryptolaemus affinis*.

PLANT INTRODUCTION AND QUARANTINE STATION, LALOKI.

The Plant Introduction and Quarantine Station, Laloki, is situated 15 miles from Port Moresby in an area which might be termed an ecological island. It is an irrigable fertile river flat, surrounded by poor eucalypt savannah which is not likely to be developed for purposes other than grazing, so that any outbreak of introduced diseases is unlikely to be able to be spread to plantation areas. The station is almost at sea level with an annual rainfall of 40 inches, lying, as it does, near the centre of the Papuan rain shadow belt. The property comprises 800 acres although a large part of this is eucalypt savannah and the quarantine area proper comprises only about 1 acre. Approximately 60 acres are cultivated as there are, in addition to the quarantine area, multiplication areas and seed increase plots.

The quarantine area has an insect-proof shade house and facilities for hardening. It is separated from the multiplication area by a barrier kept under a crop such as the pineapple. All official introductions of plant material to the Territory, with the exception of seeds of certain types which are permitted less restricted entry, are made through this Station and a certain amount of material is quarantined for members of the general public. Being near Headquarters, the Officer-in-charge can report any outbreaks of pests or diseases which occur, and periodical routine inspections of all quarantine material are carried out by the Headquarters' pathologists and entomologists.

Contact was maintained throughout the year with research institutions, botanic gardens and Departments of Agriculture in many parts of the world for the purpose of obtaining and exchanging plant material. The Department was most fortunate in receiving such generous responses from overseas authorities. As in previous years, introductions were kept to a minimum, being made only when there was a definite need and justification to meet research or developmental requirements of the Territory. Introductions for the year are classified according to economic use in Table 34 and according to the country of origin in Table 35.

TABLE 34.—CLASSIFIED LIST OF INTRODUCTIONS 1959–60.

Cereals:			
Broom millet	1		
Sorghum	1		
			2
Pasture and Forage Crops:			
Pasture grasses	1		
Shade crops	9		
Cover crops	2		
			12
Oil Crops:			
Peanuts	55		
Soybeans	21		
Castor bean	3		
Oil palm	2		
			81
Fibres:			
Cotton	6		
Sisal	6		
Manila hemp	2		
			14
Stimulants and Spices:			
Tobacco	3		
Spices	4		
Capsicum	2		
			9
Rubber:			5
Fruits:			43
Vegetables:			10
Ornamentals:			29
Virus Indicator Plants:			56
Miscellaneous:			5
For Quarantine Observation:			151
	Total		417

TABLE 35.—PLANT INTRODUCTION—COUNTRIES OF ORIGIN 1959–60.

America			51
Pacific Region:			
Fiji	2		
Hawaii	33		
Netherlands New Guinea	16		
New Zealand	1		
			52
Asia:			
Ceylon	11		
Hong Kong	3		
India	14		
Indonesia	78		
Japan	1		
Malaya	6		
North Borneo	3		
Singapore	46		
Thailand	2		
			164
Africa:			
Libya	4		
South Africa	1		
			5
Europe:			
Italy	1		
			1
Australia:			
C.S.I.R.O.	78		
University Sydney	7		
Department of Agriculture, Queensland	6		
Department of Agriculture, New South Wales	6		
Department of Agriculture, Victoria	2		
Private	1		
Commercial	44		
			144
		TOTAL	417

To facilitate the introduction of planting material from Malaya, negotiations were commenced during the year to conclude an inter-governmental exchange agreement with this country. The Territory is interested mainly in rubber and tropical fruit trees from Malaya.

The most important introductions made during the year were as follows:

TOBACCO.

There is an upsurge of interest in tobacco growing in the Territory and three air-cured varieties were obtained from the United States of America for multiplication and distribution. All three appear very promising and the leaf is suitable for twist manufacture.

TROPICAL FRUITS.

Small numbers of grafted fruit trees were obtained from Netherlands New Guinea and seed of various fruits from the Royal Botanic Gardens at Kandy, Ceylon. In addition, three improved mango varieties were received from North Queensland. Practically all mangoes in the Territory have stringy fruit with a turpentine flavour so that there is considerable scope for the introduction of better types. Improved varieties of fruit trees were also imported from commercial nurseries in Australia and an interesting possibility presented itself of trying stone fruit such as peaches in the Highland regions which are subject to regular frosts. Three varieties of peaches with a very low chilling requirement were introduced from a commercial breeder in Queensland and sent to the Western Highlands for trial planting at Wabag.

SPICES.

The Territory is deficient in spices, having made very few introductions in the past. Seed of cinnamon (*Cinnamonum zeylanicum*) was obtained from the Botanic Gardens at Singapore and three introductions of nutmeg (*Myristica fragrans*) were made, two from Netherlands New Guinea and one from Malaya. The seed germinated well and growth has been excellent.

Oil Palm (*Elaeis guineensis*).

Two additional oil palm types were introduced from commercial sources in Malaya being *dura* x *tenera* and *tenera* x *tenera* types. They are established at Epo.

Manila Hemp (*Musa textilis*).

Seed of two varieties of manila hemp, Tangongon and Bongulanon, were obtained from North Borneo in order to extend the range of material available for selection in the Territory. Various acid treatments were tried in an effort to break the dormancy of the seed, but only an odd seed germinated out of 10,000 of each variety imported, though there may be further germination in later months.

Cotton (*Gossypium hirsutum*).

Cotton is a possible alternative crop in the drier regions of the Territory and the leading commercial varieties were introduced from Queensland, together with some American varieties.

Soya Beans (*Glycine max*).

A wide range of soya bean varieties was introduced from the Commonwealth Scientific and Industrial Research Organization of Australia and the United States Department of Agriculture. After multiplication at Laloki, the varieties were distributed for field trial.

Peanut (*Arachis hypogaea*).

Over 60 varieties were introduced from the Commonwealth Scientific and Industrial Research Organization. Many originated in the Philippines, Indonesia and America and most had been assembled by this Department's Plant Introduction Officer when seconded to the F.A.O. in Indonesia. A fresh introduction was made of the variety Schwarz 21 as the plantings of this variety in the Gazelle Peninsula had developed virus symptoms.

Leucaena (*Leucaena* spp.).

There is a continuing programme of introduction of shade species. During the year, selections from the cross *Leucaena glauca* x *L. pulverulenta* were obtained from Netherlands New Guinea. At this early stage, they do not exhibit obvious heterosis and have not grown as quickly as the three strains of *L. glauca* introduced last year from El Salvador, Guatemala and Peru. In the course of observations made during the year, it emerged that the *L. glabrata* seed obtained from Uganda about seven years ago, trees from which are growing at Laloki, was probably impure and the majority of the trees are apparently *L. glabrata* x *L. glauca* hybrids. The small amount of seed set on these trees is therefore not *L. glabrata* and is probably back-crossed with pollen from *L. glauca* growing on the station. One small tree of different type is growing in the row of hybrids and may be *L. glabrata*. The hybrid nature of the majority of the trees has been confirmed by counts of pinnae and pinnules, which are the same as on grafted hybrids obtained from Indonesia.

Sisal (*Agave sisalana*).

The introduction of sisal from Tanganyika has increased the range of sisal material available in the Territory.

Castor Bean (*Ricinus communis*).

Introductions were made from the Transvaal. All were tall varieties suited only to hand cultivation.

Other Activities.

The station serves also as a multiplication and distribution area for citrus trees budded with certified stock. About 1,000 trees were budded and distributed to Agricultural centres or sold to the public.

Considerable areas of *Crotalaria anagyroides*, *Centrosema pubescens*, *Pueraria phaseoloides* and *Leucaena glauca* are maintained on the station for seed production. About 1 ton of *Crotalaria* seed, ½ ton of *L. glauca* and appreciable amounts of *Centrosema* and *Pueraria* seed were sold to the public during the year.

Nut Grass (*Cyperus* sp.).—Infestation is a serious problem in the quarantine and multiplication areas. Only limited success has been obtained in spraying trials and an attempt to shade out nut grass with black polythene sheeting failed: the growing plant lifted the plastic which cracked very quickly because of weathering and the growth came through.

PLATE 13—*The effect of mineral deficiencies on the growth of maize at Yambi.*
(*a*) *Minus phosphorus.* (*c*) *Minus nitrogen.*
(*b*) *Minus minor elements.* (*d*) *Minus lime.*

[Photographs A. W. Charles]

EXPERIMENTAL PLOTS, YAMBI.

Yambi is situated on the Sepik Plains on the Maprik/Pagui Road. It comprises approximately 2,000 acres of almost flat grassland. The rainfall is in excess of 100 inches per annum, seasonally distributed, but with no month averaging less than 3 inches. The area was acquired to investigate the problems of land utilization and economic cropping. The Sepik Plains comprise some millions of acres of flat to gently rolling topography intersected by tree lined gullies. About half the area consists of grassy plains, which are well-drained on the slopes but pot-holed and poorly drained on the flats, with some swampy vegetation, the other half of the total area being sago (*Metroxylon*) swamps. There is practically no population on the plains proper, cultivation being confined to the tree-lined gullies which intersect the area. The sago swamps are also exploited for food.

The soils are generally of a podsolic type, very acid with a quartzitic top soil overlying a compacted clay horizon, sometimes laterized and with markedly impeded drainage. Yambi is located on what appears to be typical of the poorest parts of the plains.

Trials laid down initially utilized rice and maize as test crops. The first trials were omission method fertilizer trials with and without drainage. They demonstrated the extreme deficiency of phosphorus on virgin soils, moderate deficiency of potash, moderate deficiency of at least one still-undefined minor element and possibly a deficiency of calcium, although it is uncertain whether the response to liming was a calcium response or a reaction to amelioration of the pH. No matter what rate of fertilizer application was used, maize and rice produced virtually no yield unless phosphorus were included in the mixture. A sowing of rice without fertilizer did not return the seed sown and the " minus phosphorus " maize plots did not yield any seed at all. Some of the results with maize are shown in Plate 13.

The isolated situation of Yambi makes the price of fertilizer high and it is difficult to see how the plains may be utilized economically. However, the appreciable population pressure of the large and expanding population in the Torricelli and Prince Alexander Mountains is such that investigations have been continued in the hope that a reasonable form of utilization might be found. Effort has been concentrated on examining the residual effects of fertilizer, especially phosphates, and the use of crops, especially flooded rice, which might be more tolerant of the low fertility conditions. Attempts have also been made, without much success, to establish pastures. It is planned that cattle will shortly be introduced and their performance compared on natural pastures unfertilized, natural pastures fertilized, natural pastures supplemented by mineral licks only, and fertilized improved pastures.

PLANT PATHOLOGY.

Plant pathological laboratories are located at Port Moresby and Keravat. The Principal Plant Pathologist has her headquarters at Port Moresby and works primarily on plant disease identification and research into diseases of fungal origin. The Microbiologist, concerned principally with the study of nitrogen fixing Rhizobium on legumes, is also stationed at Headquarters. A Virologist is located at Keravat.

Microbiology.

Maintenance and Supply of Rhizobium Stock Cultures.

Growers throughout the Territory now commonly inoculate leguminous covers and shade trees with cultures of nitrogen fixing bacteria of the genus *Rhizobium*. The following inocula were supplied:

Leucaena glauca	2,421 bottles.
Medicago sativa	4 bottles.
Pueraria phaseoloides	1 bottles.
Stylosanthes gracilis	3 bottles.
Trifolium pratense	4 bottles.
Glycine max	4 bottles.
Centrosema pubescens	9 bottles.

Inoculum was distributed to all parts of Papua, New Guinea, Netherlands New Guinea, and Florida, for the West Indies. Record sheets were sent to selected places in the Territory and also to the West Indies for recording differences in height, colour, and nodulation of inoculated plants, when compared with the uninoculated plants which each grower was asked to sow at the same time.

Efficiency Tests of Rhizobium Strains.

In order to ensure that only the most effective strains of Rhizobium would be sent out, efficiency tests were set up during the year. Eleven strains of Rhizobium were tested on *Leucaena glauca*, the effectiveness being determined by the height of the plants and the number of effective nodules produced. Strain M1 was best and is supplied as the standard culture for *L. glauca.*

Efficiency tests of a strain of Rhizobium isolated locally from *Centrosema pubescens* showed that it was superior to other strains imported from Australia in respect of the amount of nitrogen fixed and the dry weight of plants produced. Similar efficiency tests were carried out with Rhizobia on other legumes including *Lotus uliginosus*, *Pueraria phaseoloides*, *Arachis hypogaea* and *Stylosanthes gracilis.*

Isolation of Rhizobia from Different Legumes.

Isolations were made from the following hosts:

Albizzia stipulata.	*Glycine max.*
Arachis hypogaea.	*Leucaena glauca.*
Calopogonium muconoides.	*Lotus uliginosus.*
Centrosema pubescens.	*Pueraria phaseoloides.*
Crotalaria anagyroides.	*Stylosanthes gracilis.*

Many of these isolates have not yet been tested on their respective hosts, and some may not be effective, although all eleven isolates obtained from *Leucaena glauca* have been shown to produce effective nodules. The following properties of all isolates were determined:

(i) Growth on different media, including potato slopes and agar media, using different sources of vitamins and varying nutrient element balance. The media had an effect on colony morphology.

(ii) Nodulation of the host in a variety of soils.

(iii) Nodulation of the host in plant tubes. *Pueraria phaseoloides*, *Centrosema pubescens*, *Vigna sinensis*, *Glycine max* and *Arachis hypogaea* and others produced successful nodulation in plant tubes.

(iv) The degree of specificity of the isolates.

They will later be tested for effectiveness.

Other Studies.

Other investigations aimed to find the best methods for growing large tropical leguminous cover plants under sterile conditions for Rhizobium studies in the laboratory and glasshouse.

Studies have been made on the effect of pre-treatment of seed of the tropical legumes. Poor germination is obtained unless such seed is treated before planting and this becomes particularly important in controlled experiments with a minimum number of seeds per plot. The effects of wet heat, abrasion, and treatment with concentrated sulphuric acid were studied. Hot water treatment was not only the simplest but also the most effective treatment.

In an attempt to minimize moisture loss from plant tube media, glycerol was added and its effect was studied on the growth of Rhizobium, the consistency of the media and the development of contaminants.

An unfinished series of tests is proceeding to study the effect on nodulation of *Leucaena glauca* of the addition of nutrients to an acid soil from Sogeri.

Virology.

Virus on Cucurbita Moschata.

Investigations were concluded on a virus attacking *Cucurbita moschata* Duchesne at Keravat, New Britain; it was found to be a strain of melon mosaic virus. The host range is restricted to the systemic infection of Cucurbitaceae, including *Trichosanthes anguina* L., and local lesion reaction on *Chenopodium amaranticolor* Coste et Reyn. The thermal inactivation point lies between 57 and 60° C. for an exposure of 10 minutes, dilution end point between 10^{-3} and 10^{-4} and longevity *in vitro*, 72 to 96 hours. The virus is sap transmissible and is also transmitted by an aphid, *Aphis gossypii* Glover. This work has been published in the following paper: " A Strain of Melon Mosaic Virus on *Cucurbita moschata* Duchesne in New Guinea "—R. J. van Velsen; *Papua and New Guinea agric. J.*, **13**, (1): 36–38 (1960).

Mosaic of Centrosema and other Legumes.

Work proceeded on the identification of the mosaic virus of *Centrosema pubescens*, *Desmodium distortum*, *Calopogonium mucunoides* and *Crotalaria* spp. Host range studies and mechanical and insect transmission tests have been carried out.

Chlorotic spot of Passiflora foetida.

Studies on the symptomatology, identity and transmissibility of chlorotic spot virus were carried out on *Passiflora foetida* and other species in this genus.

Chlorosis of Schwarz 21 *Peanuts.*

Chlorosis of this variety of peanuts is being investigated, the work including methods of transmission and host range studies.

Sweet Potato abnormalities.

Three abnormalities of sweet potato, provisionally designated " feathery mottle ", " yellow veining " and " laminar variegation " are being studied. Transmission tests have already been carried out and host range studies will follow so that comparisons with conditions already described overseas can be made.

Taro abnormalities.

Abnormalities occurring in taro have been collected at Keravat and will be studied in the future. The conditions are provisionally designated " leafcrinkle ", " petiolar swellings " and " stunted plants ". Colour striations of the petioles are also under observation.

Cassia mosaic virus.

Transmission and host range studies have been carried out on species of *Cassia* and on other legumes and indicator plants in an attempt to identify this virus, and the work is continuing.

Other virus investigations.

Other virus conditions being investigated include those on Aibika (*Hibiscus abelmoschus*), *Axanopus* sp. and *Abutilon* sp., *Hippeastrum* and other species.

General Pathology.

Identification Service.

During the year, 460 accessions were handled at the Moresby laboratory and 273 collections made during an intensive survey in Netherlands New Guinea with Mr. A. Johnston. The specimens were from the general public or agricultural officers and those collected during field investigations and on surveys.

Specimens in good condition were lodged at the Moresby Herbarium. Portions of many of the collections were forwarded to the Commonwealth Mycological Institute, for lodging or for confirmation or identification. Specimens and/or cultures, slides or photographs for certain other specialists were also forwarded during the year, e.g., Barnet and Green, West Virginia (*Choanephora cucurbitarum*); Nobles, Ottawa (*Polypora sanguineus*); Storey, Kenya (*Puccinia polysora*, and stem girdling of coffee); Turner, Ghana (*Phytophthora palmivora*); Bridge Cook, Cincinnati (Cyphellaceous fungi).

As well as to the C.M.I., specimens were forwarded to Mains, Ann Arbor, United States of America (Entomogenous fungi); Reid, Royal Botanic Gardens, Kew (Basidiomycetes, also hallucinogenic fungi for Singer, Argentina); Fisher, Waite Institute (nematodes).

Many of the records were new for the Territory and some are apparently new species and a few new genera. These will be described by the Pathologist at Moresby or by overseas specialists.

Slides of the accessions are maintained at Moresby, together with cultures of some of the causal organisms.

The main cultural work carried out during the year was the isolation of organisms from the various accessions for identification and study. Services also included advice to and interviews with the public, commercial representatives and officers of the Department, on disease problems and aspects of quarantine.

Check List of Territory Diseases.

The compilation of the Check List will be terminated towards the end of the year (i.e., after five years of the present pathology service). The Check List of diseases recorded during that time will be published together with all previously published records. In the future, additions to the Check List will be published annually or whenever they occur, whichever is more appropriate.

Field Investigations and Surveys.

Investigations into various conditions in the field and the continued survey of diseases present in the Territory were continued as follows:

White Leaf-streak of Rice.

Investigations carried out in conjunction with Deighton of the Commonwealth Mycological Institute, Kew, England, were concluded on a white leaf-streak of rice caused by a new species of fungus, *Ramularia oryzae*. The disease has been shown to occur in Papua and New Guinea, British Solomon Islands Protectorate, North Borneo, Sierra Leone and Nigeria. These studies have been published in the following paper: " White Leaf-streak of Rice Caused by *Ramularia oryzae* sp. nov."—F. C. Deighton and Dorothy E. Shaw; *Trans. Brit. mycol. Soc.*, **43**, (3): 516–518 (1960).

Observations on Diseases of Cacao Pods.

Investigations were concluded on the " black pod " condition as it occurs in the Gazelle Peninsula in New Britain. It was found that there was one component of this condition caused by the fungus *Phytophthora palmivora* (the incidence of which is positively correlated with rainfall) and a dry-weather component from which *P. palmivora* was absent. Some evidence was obtained for field resistance to the fungus.

Work was also concluded on the condition referred to as " Cherelle Wilt " of cacao pods in the Gazelle Peninsula. It was found to consist of a pathological component and a physiological component. *Phytophthora palmivora* is directly responsible for pathological cherelle wilt (about 25 per cent. of the total wilted cherelles). Physiological cherelle wilt was most destructive to smaller cherelles (less than 2.0 cm. long). This work has been published in the following papers: " Observations on the Diseases of Cacao Pods in Papua-New Guinea.—1. Fungi Associated with Mature Pods."—L. B. Thrower; *Trop. Agric.*, **37**, (2): 111–120 (1960), and " Observations on the Diseases of Cacao Pods in Papua-New Guinea.—2. Cherelle Wilt."—L. B. Thrower; *Trop. Agric.*, **37**, (2): 121–124, (1960).

New Species.

Two new fungi were described from Territory collections during the year, viz.: *Clasterosporium cocoicola*, M. B. Ellis and D. Shaw, and *Sporidesmium eucalypti* M. B. Ellis and D. Shaw, on coconut and eucalyptus respectively. The records were published in the following paper: " *Clasterosporium* and some Allied *Dematiaceae*.—Phragmosporae 11."—M. B. Ellis; *Mycological Papers*, No. 72, 1959.

Field Behaviour of Taros to Phytophthora colocasiae.

Taros reported to have some field resistance (mainly on Bougainville) have been collected and grown at Keravat, with known susceptible varieties as controls, and all subjected to field infection. No variety has to date been found to be resistant to *P. colocasiae*, although in some the percentage infection in the field is lower than in others.

Black Pod Disease of Cacao caused by Phytophthora palmivora.

Readings on percentage loss from this disease were carried out during the year, with concomitant data on rainfall being recorded. This work will be extended during the next year.

Bougainville Plant Disease Survey.

A survey of diseases of plantation and food crops was carried out at Sohano, Buka, Numa Numa, Kieta and Buin and District. Fifty-four diseases, sooty moulds and a few miscellaneous fungi were recorded. No serious diseases were recorded, however, although blight of taro, (*Phytophthora colocasiae*) occurred on most taro throughout the island.

Plant Disease Survey in Wahgi Valley.

A plant disease survey in the middle Wahgi Valley and at Mount Hagen, with concentration on coffee and cover crops, showed that no serious disease occurred, although miscellaneous diseases of coffee, cover crops and other plants were recorded.

Investigation of Cacao Diseases on Karkar Island near Madang.

The two conditions of cacao investigated were a dieback complex and wet trunk rot. The dieback complex was in part caused by over exposure from depletion of shade, the coconut cover having been killed in various places by lightning strike. Secondary fungi only were isolated from the dieback twigs and the adjacent green wood. The wet trunk rot was somewhat similar to the symptoms reported for some types of cacao canker, but the primary pathogen has not so far been isolated: further work will be carried out on this in the future.

Investigations on the Cacao Dieback Complex in the Markham Valley.

Investigations were continued into the fungi which might be associated with this condition and will be reported on at a later date.

Survey of Plant Diseases in Netherlands New Guinea.

In conjunction with Mr. A. Johnston, Plant Protection Officer for South-East Asia, a survey of plant disease was carried out in Netherlands New Guinea, at Manokwari, Serui, Wissel Lakes, Hollandia and Bokondini. Nearly 300 collections were made, which are still being studied, and which will be reported on later.

ECONOMIC ENTOMOLOGY.

The Entomology Section of the Department is decentralized. The Principal Entomologist and one junior officer are located at the Lowlands Agricultural Experiment Station, Keravat and work primarily on pests of coconuts and cacao, and the control of the African giant snail (*Achatina fulica*). The Senior Entomologist, together with his assistant, are located at Headquarters and are concerned with the taxonomy of Departmental collections and with economic pest problems in Papua. There are also entomologists at Bubia (New Guinea Lowlands problems, especially coconut grasshoppers and cacao borers) and at Aiyura (New Guinea Highlands problems, especially coffee and food crop pests). At all centres there are laboratory facilities, and insectaries at field stations.

Visiting Specialists.

Of special interest was the visit of Dr. F. J. Simmonds, Director, Commonwealth Institute of Biological Control, during July and August, 1959. His purpose was to gain an insight into the potentialities for biological control work in the Territory both from the viewpoint of assessing the Territory's needs and to see what material might be of use in the control of pests in other countries. His special interest appeared to be in parasites of stem borers of graminaceous crops and predators of scale insects and mealybugs.

Several collectors from the Bishop Museum, including Dr. L. Gressitt, spent varying periods of time in different parts of the Territory carrying out general and specialized collecting as part of the Museum's Pacific Insect Project. Mr. R. W. Paine is spending several months in the Territory, mainly in the Gazelle Peninsula, studying the biological control of the banana scab moth and the coconut moth, *Aganoxena*. Small numbers of several species of tachinids have been reared from both pests and have been sent to Fiji. Drs. Dobzhansky and Mather spent several weeks in selected localities collecting *Drosophila* material for their respective genetical studies.

Departmental Collection and Card Register.

The expansion of the Departmental Collection, more especially the preparation of dried specimens, had to be curtailed somewhat pending the provision of additional storage space at Headquarters. However, wet-preserved specimens increased in proportion as a result.

Work is proceeding with the card register of insect pests and their hosts. Both at Aiyura and Bubia, a considerable bulk of material, general and economic, was accumulated during the year. At Keravat, collection is still confined to insects of immediate economic importance: maintenance of material in wooden store boxes is unsatisfactory, but steel cabinets provided with bottom heat and with the wells replenished with naphthalene at about three-monthly intervals are highly satisfactory under hot humid conditions.

Determination of Insects.

The number of specialists, apart from the staff of the Commonwealth Institute of Entomology, who are assisting with the determination of Departmental material, has increased considerably during the past year. The bulk of the material sent overseas still goes to the

British Museum, but they continue to be overburdened with work from many sources, with the result that determinations of some groups is long delayed. Some smaller lots sent to specialists currently working on material from the Pacific Region have been dealt with quickly. Many of these specimens include new species, and occasionally, new genera. The number of new economic records for many Territory crops continues to increase and is likely to continue to do so indefinitely as the Departmental collection is enlarged.

Extension.

Entomological exhibits were displayed at all the centres where Agricultural Shows were held.

Considerable general interest was shown in the various show cases of specimens and examples of insect damage.

There has been a marked increase in inquiries on general and specific entomological problems at all centres. This is especially evident at Port Moresby where horticultural queries are common.

As chairman of the Standing Committee on Pacific Entomology, Dr. Szent-Ivany has supplied information of an entomological nature for the Quarterly Bulletin of the Pacific Science Council and has had correspondence with biologists of a number of countries regarding the Pacific Science Congress to be held in Honolulu late in 1961.

Field Trips and Surveys.

During the year various members of the Section carried out a considerable number of field trips and surveys which covered most plantation areas of the Territory; frequently areas were visited several times either for specific purposes or as guides for visiting specialists. Among the areas visited were Bougainville, New Ireland (and several adjoining islands), Manus, Karkar Island, Sepik and Madang Districts, and most centres in Papua. For the first time, a comprehensive survey was made of the Western Highlands, during which extensive collecting was done on a wide range of native and introduced crops.

Numerous shorter trips were carried out to areas accessible to the various laboratories by road.

Pests of Economic Crops.

As before, most of the work on the economic aspects of entomology has been concentrated on the main Territory crops, coconuts, cacao and coffee. However, there are indications that rubber, especially seedlings and recently budded material, is being attacked by an increasing number of insect pests of varying degrees of severity. Their incidence as yet appears to be rather restricted. As these occurrences are usually in nurseries or in new plantings, their control should present no undue difficulty. The position regarding pests of coffee is rather of a static nature, while pests of coconuts and cacao are increasing in distribution, species involved and severity of attack.

Coconuts.

Coconut Dynastids.

There is still no indication of the spread to new centres of the introduced Rhinoceros Beetle (*Oryctes rhinoceros*), but is is spreading out from the areas where it is already established and is now present in small numbers along the Bainings coast. It is difficult to assess its importance along the East Coast of New Ireland. It is present for a considerable, but undetermined, distance, but it is considered that the local species, *Scapanes*, is of more frequent occurrence and does more damage.

Biological Control.—Recoveries of *S. ruficornis* are still restricted to the same two areas as previously, namely, Rabaul and Kokopo. However, one definite sighting was made during the year at Keravat and a possible one at Kurukakaul. The local species of the common food plant of the adult in the Carolines has been observed over a considerable area of the Gazelle Peninsula, but no wasps have been seen frequenting it.

Owing to the difficulty experienced in getting an adequate stock of female *S. ruficornis* locally, apart from the necessity of conserving stock breeding naturally, a shipment of over 200 scoliid cocoons was obtained from Koror, Caroline Island, through the courtesy of the Staff Entomologist, Mr. R. P. Owen. These all appeared to be in a healthy condition on arrival and were despatched to the Agricultural Officer, Kavieng, who liberated them in prepared compost piles at Baia Plantation where *Oryctes*-damaged palms are common. It will be several years before it is known whether they have been able to establish themselves.

The Javanese histerid, *Pachylister chinensis*, has occasionally been recovered in rotting coconuts at Keravat, but its numbers are by no means high in this medium. No search has been made specifically for it in other areas where it has been liberated. There is still no evidence of establishment of the West Indian histerid (*Leionota* sp.) or the elaterid (*Pyrophorus* sp.). The extent to which stocks of these insects were depleted by toads when released is uncertain and could be a factor in their failure to become established. Further introductions should be made later, particularly of *Pyrophorus*.

The local predatory dynastid, *Oryctoderus coronatus*, has not been encountered in mating swarms during the past year, although individual specimens have been caught at lights and occasional individuals have been found in dead oil palms.

Recently, several shipments of the large predatory carabid, *Neochryopus savagei*, have been received from Nigeria where they prey on *Oryctes* and other larvae in the loose detritus at the base of oil palms. At the present time of the year there, two or three individuals are found at the base of the majority of palms. The shipments received have been liberated in lots of about 150 each, at Keravat, Rabaul and Kokopo, the first among oil palms and the others in the vicinity of sawmills. The beetles are particularly voracious and immobilize the largest larvae by first crushing the head capsule in their mandibles, then tearing the body integument. Several beetles will congregate and feed on the large larvae. Although the beetles are semi-gregarious in habit they will attack one another if they are confined in too small a space. A small number of specimens is being kept in the laboratory for observation purposes in the hope that they will later commence oviposting. It is not intended to breed them in captivity but if they oviposit freely, the eggs will be collected and placed in suitable localities.

Observations have been attempted on the large local scoliid *Trisciloa sausserei*, but again the bulk of the population caught on the wing has consisted of males. A small shipment of two dozen females was collected by Mr. Ardley in the Markham valley and sent to Keravat. However, efforts to induce them to sting and oviposit on *Oryctes* and *Xylotrupes* larvae were unsuccessful. It is possible that the cages in which they were confined were too small (18 feet x 15 feet x 12 feet). By the time a larger cage had been constructed, the females were no longer available. Further collections will be attempted shortly.

During the past year, an attempt has been made at an assessment of the effect of indigenous predators on dynastid and curculionid larvae in several areas. On the Gazelle Peninsula, it has been found, from the examination of many dead oil and coconut palms, that predatism is negligible. Apart from *Oryctoderus* and an occasional introduced histerid larva or adult, no insect predators have been seen. Some slight action by scorpions and centipedes is evident

Examination of a relatively small number of coconut and *Metroxylon* trunks on several plantations on Bougainville and on Anir Island to the east of New Ireland, showed that a fairly wide range of insect predators is operating although often at a low level of incidence. These included histerids, elaterids and carabids, apart from a species of scoliid on Bougainville, as well as the usual scorpions, centipedes, &c. The position at Anir was particularly interesting as relatively large numbers of an histerid and a carabid were found in the only three dead sago palms that could be examined in the time available. With a view to attempting to establish these two species on the Gazelle Peninsula, a further search for them is contemplated after a series of felled palms have been decomposing for about a year. It was apparent that the Anir species were operating against the palm weevil. However, this is not considered significant as predators are generally non-specific in their feeding habits. It is thought that the type of environment they inhabit—in this case rotting palms—is a more important factor.

Chemical Control and Quarantine.—As a result of approaches by the South Pacific Commission, which was concerned about the possibility of the spread of *Oryctes* to areas at present free from the insects, notably the Solomons, a campaign of palm eradication was carried out in the immediate vicinity of the main wharf area of Rabaul. As there is still considerable uncertainty as to the maximum flying capabilities of the beetle, it was elected to clear an area of ½ mile along the foreshore in each direction from the wharf. The palms along this line were cut out and carried away for a distance of up to ¼ mile inland, the demarcation line being a wide road running approximately parallel to the shore.

Further extension of the ½ mile clearance was not feasible as it would have impinged on an area where *Scola ruficornis* was actively established. There is a sawmill located about ½ mile further along the coast from the western end of the cleared area. With the object of seeing how many beetles were actually attracted to lights, a 500 C.P. lamp was put in position over a large funnel to which a killing bottle was attached. Although the light was in operation on a number of occasions the results were almost negligible, the only catches comprising centoniids and several dynastids other than *Oryctes* (*Trichogomphus* and *Xylotrupes*).

The dusting of young coconuts in Block 402 at Keravat with DDT and BHC has been continued during the year at quarterly intervals. The loss of palms has been negligible, although the effect of extracting the beetles at weekly intervals to record their mortality is beginning to make the palms look rather bedraggled. It is proposed shortly to discontinue the weekly extractions. A number of the more advanced palms are now commencing to bear heavily. In general it may be said that the effect of the dusting is, briefly, as follows:—In the first month, in both the DDT and BHC sections, the percentage of beetles that enter the palm and are killed ranges between 80 per cent. and 90 per cent.; during the second month, the figure falls to 60–70 per cent. and in the third month, it falls again to 30–50 per cent. There is also an indication that the total numbers of beetles collected by the end of each quarter is decreasing with successive dustings. This is more marked in the DDT than in the BHC section, probably because the former is nearer the main source of re-infestation, the Oil Palm Block. From experiments in Fiji, it has been found that two newer insecticides, Sevin and Diazonon, are more effective against *Oryctes* in frond axil treatment; however the latter is considered too costly.

Oryctes Diseases.—Dr. Paul Surany, the South Pacific Commission Technical Officer investigating diseases of *Oryctes*, visited the Territory during October 1959 for a short period as part of a Pacific survey of the two principal *Oryctes* diseases which he claims are the major factors in the biological control of the insect in its original habitat.

During the year, at his request, a number of consignments of carefully-prepared dynastid larvae was forwarded to his Kenya laboratory. At Keravat, Dr. Surany preserved large series of dynastid larvae, pupae and adults for later examination. His principal interest appeared to be to obtain large series of specimens for subsequent histological examination and the taking of large numbers of photographs of adults to see whether they were showing symptoms of muscular unbalance, said to be a follow-up symptom of the diseases in the larvae. His interest in field work was limited.

The position regarding research into diseases affecting *Oryctes* is extremely difficult for a non-pathologist to assess. As Maya's Disease appears to be generally present throughout the Pacific, it would appear that, while conceding that a study of the problem may have considerable ultimate value, there is a very slender likelihood that it will have any practical use to the Pacific area in the foreseeable future. As regards Heindeneich's Disease, its presence in the Pacific does not appear to have been definitely established, although suspected cases have been found. However, in view of the fact that the nature of the diseases, if they are diseases, is unknown and particularly the fact that the mode of transmission is only suspected, it would appear that the *Oryctes* Diseases' Project has now reached an academic rather than a practical level.

As regards biological control of *Oryctes* it is becoming increasingly apparent that predators will be the ultimate means of successful control if, indeed, this is capable of achievement. The possibilities of control by predatory action would appear to depend on the establishment of as many species of predators as possible with a selection of species specifically adaptable to as many of the favoured breeding sites of the *Oryctes* larvae as possible.

Black Palm Weevil (Rhyncophorus *sp.*).

It is becoming more apparent that the Palm Weevil is the principal coconut pest in the Gazelle Peninsula. The total effect is not as evident as that of the Rhinoceros Beetle but the fact that its larvae almost invariably kill the palms they attack makes them the cause of a continuous small loss of palms which often escapes notice.

There appears to have been little work done on the control of this insect in recent years, apart from experiments in India on the effects of various insecticides poured into the affected palms. In these experiments, good results are said to have been obtained by introducing a quantity of piperonyl butoxide-pyrethrum solution into a hole bored into the palm in the vicinity of the affected area. To verify this, samples of the mixture have been obtained and applied to a number of palms. Various other insecticides are also being tested in the same experiment.

Various enquires have elicited no additional information on parasites or predators likely to be of use in controlling weevil larvae operating in living palms.

"*Sexava*".

The Coconut Grasshopper continues to cause considerable damage in the Admiraltys but, apart from this area, there have been no serious outbreaks of the insect. Experiments on various types of trunk treatments at Pak Island failed to yield useful results. The method of assessment of results of this experiment was to have been by photographic records before

the palms were treated and again a year later. No obvious effect was noted in the later photographs but this may have been masked to some extent by the fact that mature palms were being photographed from the ground and the younger fronds which were badly damaged at the beginning of the experiment may not yet have fallen.

In conjunction with the above experiment, it was noted that the Green Tree Ant (*Oecophylla*) was completely absent from the island. Accordingly attempts were made to establish it by introduction from Bubia and Keravat. A number of nests was sent from both sources and, although it is known that it is established, it is not yet known how far it has spread or to what extent it has multiplied. Efforts to obtain information on the trapping of crows have not yet been successful. It is considered that, if they are given some protection from maurauders, they may be a useful adjunct in controlling " Sexava " on a smallish island.

The grasshopper at Keravat is evident but is in very small numbers. Examination of a number of eggs recently showed that the parasitism, by *Leefmansia* only, was less than 30 per cent. Some observations on several hundred eggs showed that hatching wasps will build up the parasitism to 100 per cent. when confined to petrie dishes. This simplifies shipment and makes bulk breeding relatively simple. These observations were made with a view to exchanging " Sexava " parasites for the scoliid cocoons received from the Carolines recently. It appears that *Segestidea* spp. is causing considerable defoliation on some of the islands there.

No progress has been achieved in the search for the male of the " Sexava " strepsipteron, *Stichotrema dellatorreanum*. Many grass sweeps have been carried out on the assumption that ants are hosts of the male; material has also been accumulated as a result of light trapping but has yet to be fully sorted out. No further information has been obtained concerning the accidentally-caught tettigoniids from Linga Linga which proved to be parasitised by a *Stichotrema*, presumably *dellatorreanum*. Severe damage is reported by " Sexava " at Finschhafen on plantations and in native groves. The grasshoppers showed a moderate parasitism by *Stichotrema*.

Coconut Leafminer.

Promecotheca has been in slight evidence during the year. The worst-affected place, Linga Linga, is now recovering from its most recent outbreak but its production is still far below normal. Lindenhafen plantation has maintained good production for some time. Elsewhere *Promecotheca* has caused no concern although specimens appear to be readily obtainable if they are looked for. It would appear that consideration should be given to the introduction of one or more of the other species of parasites which were found during the original Fiji campaign against *P. reichi*; *Pediobius parvulus* was introduced before the war.

Brontispa.

Evidence of attack of palms by the Coconut Beetle is widespread and common and there is little doubt that many new plantings would get away to a much more propitious start if they were given several sprayings. An instance where this was done, rather more often than necessary, was noticed on a plantation in New Ireland. The sprayed palms were bright green in colour, vigorous and had their complete leaf-surface to work on. Unsprayed palms on adjoining plantations had a large proprotion of yellowish fronds scorched by *Brontispa* and considerable amounts of chewing by various species of grasshoppers.

A brief search for the parasite, *Tetrastichodes*, did not prove successful.

Nutfall of Coconuts.

The *Amblypelta* problem in the Territory continues to develop quite rapidly. Apart from the effect of the coreid on cacao and rubber, its effect on coconuts was studied at Aroa Plantation, Papua and at Numa Numa Plantation, Bougainville. From the Papuan species, three new species of egg parasites have been reared. Observations at Numa Numa disclosed the presence, on one block showing heavy nutfall, of an *Amblypelta* which, in all probability, is the Solomon Islands species, *A. cocophaga cocophaga*. Previously, on two occasions, specimens of this species have been collected at random towards the southern end of the island but there are no records of nutfall there apart from that caused by *Tirathaba*. No evidence of nutfall was obtained during a recent visit although signs of feeding by an *Amblypelta* were commonly seen on tapioca growing underneath palms. At Numa Numa, the species which has previously been supposed to cause nutfall of coconuts in some areas of the plantation, *A. galligonis*, was found in abundance on tapioca. However, the species found in the nutfall area was feeding, and causing typical lesions, on cacao pods directly underneath the nutfall palms indicating that it was, in all probability, the causal agent.

Although Nutfall would appear to have been present on Aroa and Numa Numa Plantation for some considerable time, its status is apparently static and it seems unlikely that it will develop into the serious problem that it is in parts of the Solomon Islands. It is of interest to note, however, that the Bougainville species moved from coconuts to cacao just as soon as the latter crop commenced to bear fruit. This may indicate that the latter will eventually become sufficiently attractive to the insect to allow it to be used as a trap crop to control coconut nutfall.

Miscellaneous Pests.

Minor pests have been noted in various parts of the Territory from time to time. As a rule, they are of strictly localized importance. A small outbreak of the Coconut Skipper Butterfly (*Cephenes* sp.) occurred at Keravat recently and caused sufficient defoliation to warrant spraying. The area affected covered about 5 acres, which is unusual for this species, as it normally confines its attention to isolated palms. Nutfall caused by the moth *Tirathaba rufivena* was observed over a wide area but it does not appear to cause significant damage. A search for the Coconut Scale, *Aspidiotus destructor*, showed that it is so efficiently controlled by predators, and possible parasites, on the Gazelle Peninsula that it can be said to be virtually non-existent.

Cacao.

The incidence and seriousness of a number of insects attacking cacao in the Territory is becoming increasingly apparent as larger areas come into economic bearing. This is especially noticeable on the Gazelle Peninsula where the number of pre-war trees, although scattered, is considerable and has formed the basis for the infestation of the post-war plantings. However, on the Mainland several species have made themselves quite apparent in a relatively short time, in the absence of large numbers of old trees.

On New Ireland, apart from the cacao termite, *Neotermes* sp., no insects have caused concern during the past year. However, on Bougainville an instance of how quickly insect species can adapt themselves to a new host in a short time was noted at Numa Numa Plantation. Since the last inspection two years ago, both *Glenea* and *Amblypelta* have developed into potentially serious problems although none of the other plantations examined has shown any variation in its insect populations during the same period.

It is becoming increasingly apparent that the stem-boring weevils and longicorns will become the most serious insect problem of cacao in the Territory. Pod-rotting and defoliating species are also capable of causing considerable damage, either consistently or periodically. However, as the main damage caused by the borers is done by the larvae feeding under the bark, they are much more difficult to control by chemical or biological means than those species whose adults, larvae or nymphs feed externally on the pods, leaves or bark.

Cacao Weevils.

There have been no records of new species of this genus (*Pantorhytes*) attacking cacao during the past year. However, two new species of the genus have been noted as damaging rubber foliage in Papua. The rate of incidence of the weevil remains extremely low in both New Ireland and Bougainville; the same applies to the Samarai and Sepik plantings. On the other hand, the various species concerned are becoming increasingly severe in the Northern District of Papua, the Morobe District and on the Gazelle Peninsula.

It is considered that attempts to control the weevil by biological means would be unlikely to produce successful results. Accordingly, attempts to control it have been concentrated on the use of insecticides, applied usually by small power-operated dusting or spraying machines carried by a single native operator.

Experiments on the control of the New Britain weevil, *P. plutus*, have been proceeding for some time. Because of the scarcity of the weevil at Keravat, these are being conducted at two badly-infested plantations about 5 and 15 miles away. Initially these were sprayed at three-monthly intervals, partly on the ground of cost and partly because it was thought that plantation labour supply would not readily be available to permit the coverage of even a moderately large plantation at more frequent intervals. Check counts of the populations of weevils on marked and control trees have been carried out regularly. The idea of using high-density spraying was abandoned early in the experiment as the provision of sufficient water proved too awkward to arrange. The insecticides are now misted on to the trees in distillate at the rate of slightly more than 1 gallon of total material to the acre. The insecticides used have been DDT and Dieldrin. Recently various additives have been added to the basic mixture as it has been found that they enhance the initial kill of weevils. The additives used are Malathion and Dipterex.

The counts of the marked trees have recently been statistically analysed. It would appear that, although spraying does produce a temporary decrease in the adult population, the interval between sprayings is too long to cause a permanent reduction in the amount of damage to the trees. This is caused by the fact that the larval stage of the weevil varies from at least eight months to as long as fourteen months. Accordingly, it has been necessary to re-arrange the trials on a new basis. Using the same insecticides, blocks have now been laid out to allow for treatment at six-, eight- and twelve-weekly intervals. A different system of check countiug of tree populations has been introduced, designed to give a more positive indication of the trend of the population following the spraying. It has been noted by observation, although it is not possible to prove it statistically, that the regular spraying has had a pronounced beneficial effect on the health of the pods generally. It is probable that the cost of the spraying on the two areas involved in the *Pantorhytes* experiments has been offset by the reduction of pod losses caused by biting and sucking insects and fungi.

Control of the Markham Valley species, *P. proximus*, has been attempted along somewhat different lines. Initially, these involved the application of a high volume spray from a tank drawn by a Ferguson tractor. Apart from the disadvantages of operating the tractor in cacao, the operators had difficulty in handling the lengths of hose conveying the spray liquid from the tank to the spraying lances.

More recently, banding experiments have been started using Ostico, a sticky banding material in which had been incorporated water-dispersible Dipterex powder. Although it has no persistence, Dipterex has a very marked knockdown effect on cacao weevils. In these experiments, several ounces of the prepared banding material were rubbed on the trunk of the tree in the vicinity of the jorquette, the principle being that, as the insect is apterous, it would have to traverse the band to reach the leaves and young bark on which it feeds. Although the banding material remains effective for several months and can be rejuvenated by rubbing the surface, the cost of the Ostico is such as to make the method prohibitively expensive on a plantation scale.

Cacao Longicorns.

The two species involved, *Glenea aluensis* in the island region and *G. lefebouri* on the northern part of the mainland, continue to be encountered in appreciable numbers on many plantations. Insecticidal control of the adults, which are extremely active, is not thought to be practicable. Control of the larvae by wiping off the larval exudate and painting the damaged tissue with 15 per cent. Dieldrin concentrate, is effective in killing up to 90 per cent. of the occupants of the channels. Prospects of controlling these insects by biological means do not seem promising.

At one plantation on Bougainville, it was noted recently that *Glenea* had over a period of two years increased from virtual non-existence to numbers sufficiently large to present a problem. In this instance, the larval population per affected tree was often sufficently high to cause death of the tree by ring-barking.

Another longicorn, *Tmesisternus sp.*, is said to be still causing damage in the Talasea area. However, the damage is said to have been brought almost under control by regular fogging with 0.1 per cent. dieldrin in distillate. The larger longicorns, *Monohammus* and *Dihammus* spp., are found from time to time in various parts of the Territory but cannot be said to constitute a problem.

Cacao Capsids.

Damage to cacao pods, and in the Markham Valley and on the Gazelle Peninsula to cacao shoots, continues to be sporadically serious in most parts of the Territory. There is no record of capsids occurring on New Ireland or Bougainville. Plate 14 shows typical severe capsid attack.

There is still no reason to doubt that capsids can be controlled almost completely by the application of two dustings of 1.5 per cent. active ingredient BHC. Subsequent limited outbreaks can be controlled as they are noticed. In the Keravat Experiment Station, this normally involves a biennial inspection and the dusting of a few dozen trees.

Recent trials at Keravat have indicated that capsids are equally susceptible to misting with an aqueous solution of insecticide as they are to dusting. The insecticides used in these trials were endrin, dieldrin and brunotox (a proprietary mixture of malathion and lindane). The cost would be appreciably less than for the dust and the amount of water required (2 gallons per acre) would not be difficult to supply. Further experiments along these lines on a larger scale are projected but these may be delayed for a time as the initial trials exhausted the stock of capsids available on the Station.

Some trials have been started to determine whether BHC causes tainting of the dried beans when it is used to control pests. The sample beans are fermented in bags with the bulk ferment. The first report on the prepared samples was unfavourable. However, this was of no assistance as the controls were equally as bad and, in several instances, worse. Further series of samples will be prepared from time to time.

Cacao Amblypelta.

The development in the feeding habits of the various species of *Amblypelta* throughout the Territory is of considerable interest. One or other of the Territory species is serious, or potentially serious, on cacao, rubber or coconuts from Papua to Bougainville. The range of their hosts among food and ornamental plants is also increasing considerably. Random specimens of a species close to *A. cocophaga malaitensis* have been taken as far inland as Wau.

On Bougainville, a recent record of what appears to be the Solomons Nutfall *Amblypelta* (*A. cocophaga cocophaga*) was made at Numa Numa Plantation. Here the coreid was found attacking cacao pods in a block interplanted among coconuts. As the latter were suffering heavy loss from Nutfall, it is most likely that the above insect was the cause of both types of damage. On the same plantation, *A. galligonis* was noted in considerable numbers on tapioca. It seems improbable that this species normally attacks coconuts as signs of its activity were noticed on tapioca as far south as Iwi Plantation, but the only Nutfall noted was caused by *Tirathaba.*

On New Britain, the local variety of *A. costalis* has not been seen on cacao during the past year; it was also very seldom found on tapioca and cannot yet be considered a pest. Cage trials have shown that the adults are capable of causing the fall of young nuts; in several cases, a single feeding scar was sufficient to cause Nutfall.

The Madang species (*A.* sp. nr. *ardleyi*) declined markedly in numbers during the past year. In the Markham Valley, *A. theobromae* is causing considerable damage at the present time especially in too heavily shaded areas adjacent to primary forest. Instances of severe damage by the same species were reported on several plantations in the Popondetta area.

Defoliating Insects.

The principal species causing defoliation of cacao, particularly of the young flush, are the cupmoth, *Pinulenza kukisch,* the looper caterpillar, *Ectropis bhurmitra* and the noctuid, *Achaea janata.* The first species is active mainly in the Madang District where it is capable of causing periodical extensive defoliation over large areas. The looper appears to cause damage only in the Gazelle Peninsula where the defoliation, although intermittent, is usually extensive. The noctuid, although probably occurring throughout the Territory, has been known to cause trouble only on the Gazelle Peninsula and in the Markham Valley. It is capable of attacking hardened leaf tissue when the larvae are abundant. Several species of tortricids cause damage to the growing tips of young cacao. However, as their population generally remains fairly low, they are seldom the cause of extensive damage.

There have been no reports of the recurrence of the outbreak of *Pinulenza* which occurred on Karkar Island several years ago and caused considerable damage until the moth was brought under control as the result of a comprehensive spraying programme. The extent to which the activities of the indigenous parasite, *Brachymeria,* contributed to this reduction in the pest population is unknown although it is capable of reaching a high rate of parasitism at times. Reports of severe outbreaks of the insect occurred in several parts of the Madang District but they were brought under control by the use of dieldrin sprays. All three species appear to be most prevalent in cacao which is in undershaded blocks, although when *Ectropis* is present in high numbers, the degree of shade becomes of less importance and the insect can survive in heavily-shaded cacao.

Other minor foliage pests include various species of small circulionids, cetoniids, eumolpids and galerucids. Several species of the eumolpid genus *Rhyparida,* can cause considerable damage to the young leaves of individual trees but they do not generally occur over large areas at the one time.

Bark-chewing Insects.

There is only one species of importance under this heading. This is the xyloryctid moth, *Pansepta teleturea.* To date it has been observed as a major pest only on the Gazelle Peninsula but it is being recorded from an increasing number of localities on the mainland. It appears to be seasonal in occurrence and when it reaches its peak it is capable of causing the death of branches up to three or more inches in diameter. As with many other insect pests of cacao, its main damage is done in areas where the host is in an exposed position.

PLATE 14—*Capsids, if uncontrolled, may cause severe damage to cacao pods.*
[Photograph L. Smee]

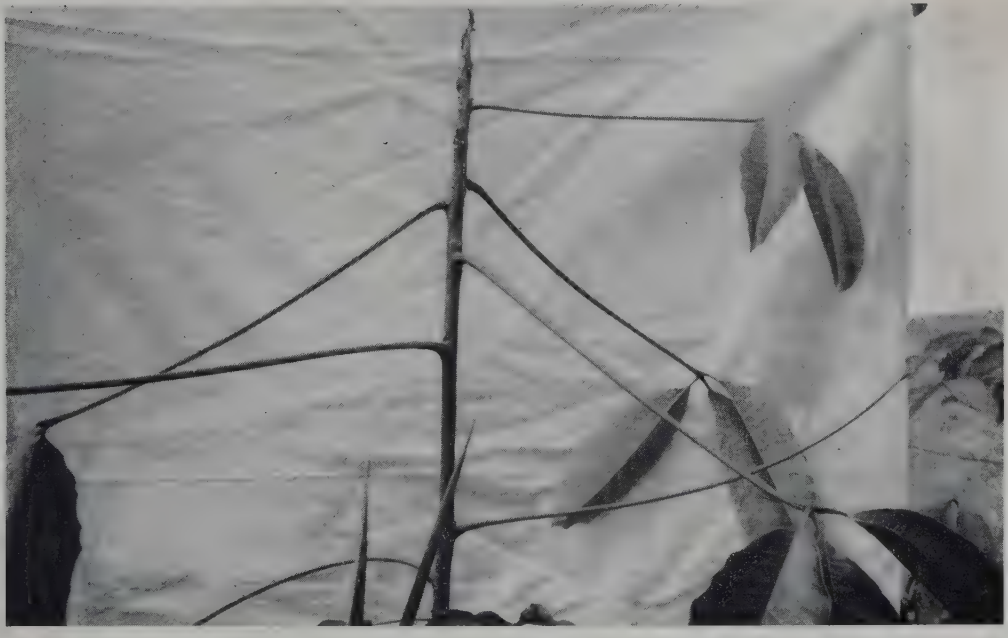

PLATE 15—*Tip dieback results from the feeding of* Amblypelta *on young rubber.*
[Photograph J. J. H. Szent-Ivany]

Preliminary trials on the control of this insect indicate that the larvae are provided with a considerable degree of protection from insecticides by the webbing and frass covering under which they feed. The addition of a wetting agent to the spray is indicated to ensure penetration of the covering. However, during recent months, the moth has been occurring only sporadically in the vicinity of the Station and additional trials have been postponed on this account. Some observations on the bionomics of the species have been made but more detailed work is being deferred until the Station glasshouse is completed. The same applies to work on several other species of cacao pests, field supplies of which are either scarce on the Station or absent altogether.

The other species attacking the bark of the tree are of interest rather than importance. The aegeriids, *Conopia theobromae* and *Conopia* sp. occur widely on the Gazelle Peninsula but usually attack only isolated trees and the latter are often in an unthrifty condition.

Pod-Boring Insects.

These are encountered much less frequently that the pod-sucking insects such as the capsids and *Amblypelta*. They are markedly seasonal in their occurrence and normally occasion loss only when their peaks occur during a period of wet weather. Their effect is most often indirect by allowing the ready entry of secondary pod-rotting fungi.

The main species occurring on the Gazelle Peninsula is the tortricid, *Olethrutes sp.* As the species is usually rather scarce at Keravat, detailed observations on its life-cycle are also waiting on the completion of the glasshouse.

Cacao Termites.

The incidence of the cacao termites, *Neotermes* spp., appears to be increasing steadily on the Gazelle Peninsula. There is also the first evidence in New Britian that the local species is developing a capacity, similar to that of the New Ireland species, of being able to enter a seemingly healthy cacao tree underground by way of the tap and secondary roots. The amount of termite damage at Keravat is kept at a minimum by the regular removal of dead branches and their treatment where necessary. However, many instances have been noticed where neglect of this treatment is allowing a steady build-up of infestation.

Where the normal method of entry is by way of dead branches, the treatment is simple as mentioned already. However, where the insect enters a healthy tree via the root—often from an infected stump nearby—detection of its presence is often not possible until the tree is in a marked state of decline. From limited observations made at a particularly badly infested plantation in New Ireland, it is indicated that it is possible to get some degree of protection, and to save some trees already badly damaged, by applying a small quantity of an arsenical to the base of the tree and lightly forking it into the ground. As below-ground infestations do not show external symptoms of attack until a large colony has built up inside the trunk, it would probably be necessary to treat all the trees in an area known to be affected by this type of attack. There is evidence that the arsenical treatment is capable of exterminating a colony in a tree when the latter is very heavily attacked. However, more work is necessary on this problem before the method can be recommended definitely.

Coffee.

Experiments on the control of the Coffee Ring Borer (*Meroleptus cinctor*) have been expanded to include insecticides besides dieldrin. A trial to control the weevil in the nurseries suggested that virtually complete control might be achieved by the use of 0.2 per cent. dieldrin with subsequent treatments at yearly intervals or perhaps less frequently. A commencement has been made with a campaign to effect the control of the weevil in Native plantings and it is estimated that some 400 acres have already been treated.

Studies of the bionomics of the ring borer and the coffee leafhopper under laboratory conditions are continuing but the latter is proving a difficult subject to work with. Observations were carried out on a number of entomophagous fungi affecting a variety of insects including the coffee ring borer. Perhaps owing to the seasonal conditions, the mortality rate was found to be high.

The incidence of the defoliating weevils (*Oribius* spp.), appears to have been slight during the year as was also damage by the Coffee leafroller (*Homona coffearia*).

Damage to the foliage of shade trees by various case and cup moths was observed on a number of occasions. However, the extent of the defoliation was not severe and the trees recovered of their own accord.

Rubber.

Of the four major primary crops of the Territory, rubber, until the past few years, has been singularly free from attack by insect pests. However, closer recent examinations have shown that the crop is attacked by quite a number of species, several of which have started to assume a position of some economic importance. This is especially apparent in Papua although outbreaks are usually still restricted to highly localised areas. At the moment, most of the damage appears to occur in seed beds and the flush of young trees and control by chemical means should present no undue difficulty.

The most frequently-occurring species in Papua is *Amblypelta lutescens papuensis*. This was first noticed in seed beds several years ago where it was causing typical feeding scars in young tissue, and tip dieback. It proved to be amenable to standard insecticide treatment and should cause little trouble provided its presence is noticed at an early stage. The host range of the species is steadily being widened as more observations are made. During the year, three new species of egg parasites were bred from this species in Papua. These differ from the egg parasites occurring in the Solomons and suggest the possibility of their use in a mutual biological control experiment at a later date. Plate 15 illustrates typical *Amblypelta* damage.

Other insects recorded on rubber in Papua, sometimes in large numbers, were the flattid *Colgar tricolor*, the noctuid *Tiracola plagiata*, the curculionids *Idiopsis grisea* and *I. coerula*, as well as two undetermined species of *Pantorhytes*.

Giant African Snail.

No reports have been received to indicate that the Giant Snail (*Achatina fulica*) has reached new parts of the Territory during the past year. Normal outward spread is occurring on the Gazelle Peninsula and the opening up of the Warangoi blocks has increased their activities there, indicating that considerable trouble may be expected from this source during the next few years. Along the East Coast Road in New Ireland, the snail has almost reached Namatanai but its occurrence is discontinuous, suggesting that it has made use of motor transport to aid in its distribution.

The introduced predatory snail (*Gonaxis kibweziensis*) is continuing to increase steadily in numbers at two of the four original liberation sites. At one of the other original sites the snail is only moderately abundant and it has not yet been recovered from the fourth.

Distribution of the snail from the two main sites has been carried out on a number of occasions whenever numbers appeared to warrant collection. Usually, batches of 50–100 half to fully-grown individuals are sent out at one time. Apart from a further shipment to Hansa Bay, several batches have been sent for release at various points along the East Coast of New Ireland and approximately one dozen batches have been distributed throughout the Gazelle Peninsula. Currently an attempt is being made to establish the snail in the new Warangoi areas.

No findings of the Florida Predatory Snail (*Euglandina rosea*) have yet been made. It appears that it may require a somewhat more temperate climate for establishment.

The general effect of the absence of the Giant Snail on the economy of plantation running was most obvious during a recent visit to Bougainville. In the two years since the last visit, most of the plantations seen have achieved almost a full cover of legumes, a result which would have been impossible in an area infested with snails.

Spraying and Dusting Equipment.

With the increased losses which can be caused by insect pests, particularly on cacao, a marked increase in the acquisition and use of small power-operated dusting and spraying machines is apparent. This interest is evidenced by the number of types that are procurable *ex* stock in the Territory.

Of the machines that were available at Keravat previously, it has still not proved practicable to use the Micron or the Micronette. Mechanically, they are difficult to maintain and their range of use under New Guinea conditions appears limited. Continued use of the " Fontan " and the " Motoblo " has occurred during the past year with only minor defects noticeable. Several other machines of a similar nature have been tried out for various importing firms and these have been quite satisfactory, apart from minor defects caused mainly by the use of inferior materials in incidental parts of the machine, generally items which can be readily rectified by the owner.

There would appear to be no basis for the statement that the machines are beyond the capacity of the average Native operator to carry. Even small Natives are able to carry machines for 4–5 hours with rests only for re-fuelling operations. However, it is usually better to allocate two Natives to a machine so that they can alternate the various operations involved, especially if rather large areas have to be covered. It is also becoming evident that the useful life of these small machines is likely to be shortened if their care is left entirely in the operator's hands without a reasonable amount of supervision. Much inefficiency in output can be eliminated by running water through the machine after the day's work, thus cleaning the tank and clearing the output lines and jets.

Food Crops.

There was no occasion to carry out any specific work on pests affecting subsistence food crops. However, many observations were made on a wide variety of these crops and numerous specimens were collected over a wide area. Attempts to carry out experiments on the control of insects attacking European vegetables—which are becoming quite important as a cash crop to Natives on the Gazelle Peninsula—have largely been vitiated by the virtually continuous wet weather that has been experienced at Keravat for many months past. Damping-off and related fungi caused most of the difficulty in the seedling and early-planted-out stages.

Ornamental Trees and Shrubs.

Several species of leguminous ornamental trees are being severely attacked by a range of species in various parts of the Territory and intermittent observations and control trials have been carried on several of these. At Port Moresby, the Poinciana noctuid, *Pericyma cruegeri*, caused considerable defoliation for the third year in succession. Gammexane (50 per cent.) dispersible powder was found to give worthwhile control.

At Keravat, the continued heavy incidence of the pierid *Catopsilia* sp. has been such as to destroy all the *Cassia nodosa* trees on the station despite continued spraying. Control is rendered difficult by the fact that other species of *Cassia* growing nearby are tolerant of the insect, but provide a continuous reservoir for re-infestation for the highly susceptible *C. nodosa*. Control of the caterpillar by the usual insecticides is possible, but continued control is spoiled by the fact that the new flush is unprotected by the last application of insecticide and so the cycle continues. The station Poincianas and Peltophorums have also been badly defoliated during the past two years, the former by a psychid and the latter by a tortricid. As these trees are now quite tall, full coverage using the small powered machines is not possible. With all these defoliating species, it is thought that investigations into their biological control could well lead to useful results.

Miscellaneous Crops.

Incidental observations on miscellaneous crops such as cotton, maize, sugar-cane, peanuts, &c., were made during the year and a considerable number of species collected—some new to the various crops—from which various parasites were bred and recorded.

Biological Control.

The only introductions effected during the past year were the *Oryctes* carabid from Nigeria (mentioned above) and the *S. ruficornis* cocoons for New Ireland from the Caroline Islands.

Within the Territory, the Wau *Cryptolaemus* was recovered at Maprik close to where it had been liberated to combat the Yam mealybug the year before. A shipment of the same coccinellid was also sent to Choiseul Plantation, Bougainville, to aid control of mealybugs in a rejuvenated block of coffee.

AGRICULTURAL CHEMISTRY.

There are two chemical laboratories, located respectively at Port Moresby and Keravat. The Principal Chemist and most of his staff work at Port Moresby but the Keravat laboratory, which investigates problems of plant nutrition for the most part, is important as it enables research to be carried out in a locality where much plantation activity is centred.

During the year extensions were made to the Port Moresby laboratories to provide additional storage, a sample preparation room, an air-conditioned laboratory and a photographic darkroom. A glasshouse shared with the Pathology Section was also erected. With the expansion of the Soil Survey Section and the consequent greater demand for soil analyses, plans were implemented for re-designing and equipping a laboratory building at the Kila Quarantine Station as a soils laboratory. Occupation should be possible in the coming year.

The Chemistry Section is frequently called upon to undertake analyses for Departments of the Administration other than the Department of Agriculture as there are no other chemical laboratories in the Territory. However, its prime work and responsibility is in the Department of Agriculture, Stock and Fisheries, in the fields of soil and plant analysis in connexion with soil and land use surveys, agronomic experiments, especially fertiliser trials and planting and re-planting programmes, pasture improvement and management, and analyses of agricultural products in connexion with quality control.

With the establishment of an additional Soil Survey team in the field, the number of soil samples received exceeded the capacity of the Chemical Section, particularly as there was concurrently a drive to overcome the backlog of unanalysed soil samples.

Chemical studies in connexion with the cacao problems in the Markham Valley were continued and extended to include cacao nutrition generally.

Foliar methods of diagnosis have been expanded and are being used in conjunction with soil analysis in a survey of the fertility status of the main areas of agricultural importance.

Comprehensive studies of Territory copra quality and methods of sampling shipments were continued.

Pyrethrins analysis of *Pyrethrum* strains from Aiyura were continued and indicated that many strains were of satisfactory quality.

Pasture analyses were carried out, mainly in connection with feeding trials, and an investigation of the mimosine content of *Leucaena glauca* strains was initiated. A summary of the types of samples received and examined during the year is given in Table 36:

TABLE 36.—SAMPLES RECEIVED AND EXAMINED DURING THE YEAR 1959–60.

Type of Sample.	Received.	Examined.
Konedobu Laboratory:		
Soils	1,355	907
Coconut waters	135	135
Fertilizers	11	11
Fodders	33	33
Pastures	37	37
Plant leaves	177	222*
Produce	168	393*
Pyrethrum	48	38
Phytochemical	29	29
Waters	50	50
Miscellaneous	61	61
Total	2,104	1,916
Keravat Laboratory:		
Soils	158	158
Plant leaves	96	96
Total	254	254
Grand Total	2,358	2,170

* Includes samples from the previous period.

A more detailed description of investigations will now be given under the headings " Soil Analysis ", " Plant Nutrition Studies " and " General and Industrial Investigations ".

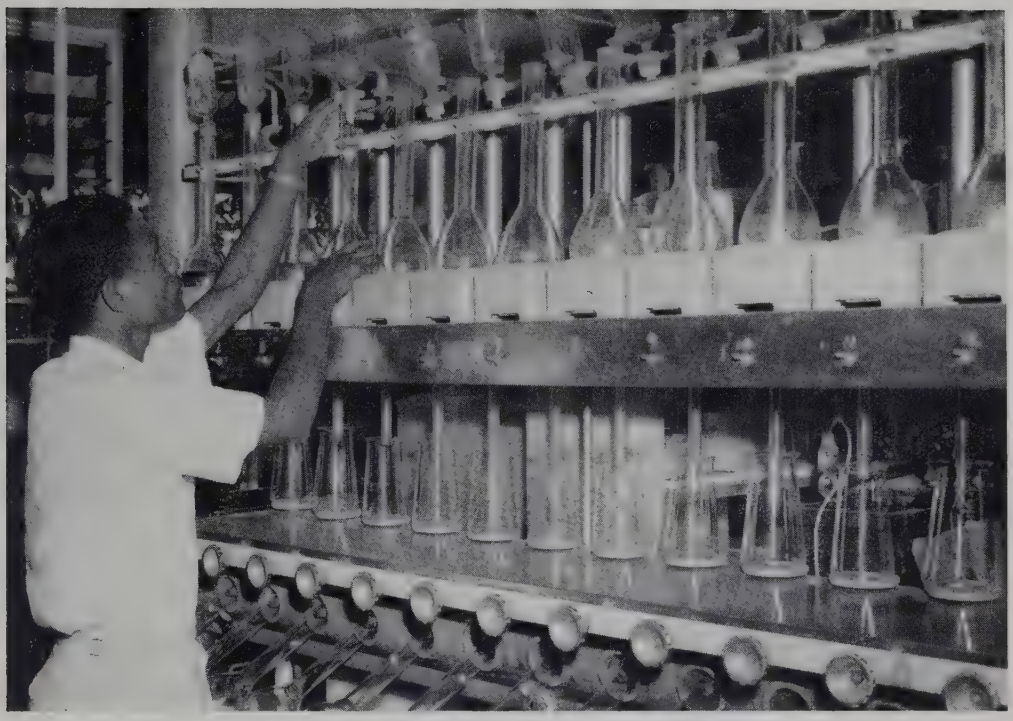

PLATE 16—*Skilled Papuan laboratory assistants carry out nitrogen determinations and similar analyses.*
[Photograph Division of Extension Services]

PLATE 17—*The Keravat Chemical laboratory is spacious and well-equipped.*
[Photograph A. E. Charles]

Soil Analysis.

Soil samples were received and examined as shown in Table 37:

TABLE 37.—SOIL SAMPLES RECEIVED AND EXAMINED.

Source of Sample.	Received 1959–60.	Examined 1959–60.
Konedobu Laboratory:		
Private Sources	210	148
Soil Survey Section, D.A.S.F.	823	389
Markham Valley Investigation	261	308*†
Other D.A.S.F.	47	47
Other Government Departments	14	15*
Total	1,355	907
Keravat Laboratory:		
Private Sources	154	154
Block 405, L.A.E.S. Keravat	4	4
Total	158	158

* Additional samples examined received the previous year. † Many of these samples were examined for pH only.

1065 soil samples were analysed in detail and approximately 500 additional samples were partially examined. This compares with a little over 500 samples examined in the previous year. In addition to official samples, the analysis of private samples is undertaken as a service to the planting community. Plate 16 shows a Papuan laboratory assistant carrying out nitrogen determinations and Plate 17, part of the Keravat laboratories.

Soil Survey Samples.

Otamata Survey, Central District, Papua.

The analysis of 194 soil samples from the Otamata survey region showed that most of the soils are neutral or slightly alkaline alluvials well saturated with calcium and magnesium but low in potassium and phosphorus.

Sowom Survey, Sepik District, New Guinea.

The analysis of 69 samples from alluvial soils in this area indicated generally poor chemical status which would limit the cultivation of tree crops.

Woitape Survey, Central District, Papua.

Analysis of 21 soils from the Woitape area revealed some acid unsaturated soils of high C/N ratio and low base status as well as low phosphorus content. Other soils were relatively fertile.

Vanapa River Survey.

36 samples received from the Vanapa River survey unit had promising chemical characteristics.

Western Highlands Survey.

Of the 440 soil samples received from the Mount Hagen region, 39 samples have been completed and the balance are in the course of analysis.

Bougainville Survey.

The analysis of 200 samples received as a result of the Bougainville survey is in an advanced stage.

Kabuna Survey.

Analysis of 33 Kabuna soil samples is an advanced stage.

Markham Valley Investigations.

As reported elsewhere, a co-ordinated investigation into the Markham Valley " dieback " condition of cacao is being carried out. The possibility of micro-nutrient deficiency has been examined. Soils were found to be highly alkaline with free carbonate at shallow depths and

the typical sickle leaf symptom of zinc deficiency was evident. Foliar spraying trials with minor element supplements have been carried out, together with fertiliser trials involving major and minor elements; pot trials are also being conducted at Port Moresby.

Other Departmental Soil Samples.

Samples of this nature are generally taken in connection with specific projects or problems under study. Analyses have been carried out in connexion with coconut fertilizer trials, rotation trials, soil exhaustion trials and areas where economic cropping is planned. Many soil analyses were also carried out in the course of an investigation into the condition known locally as " rubbery copra ".

Plant Nutrition Studies.

The plant samples analysed during the year are shown in Table 38:

TABLE 38.—PLANT NUTRITION SAMPLES ANALYSED 1959–60.

Type of Sample.	Konedobu.	Keravat.
Coconut fronds	32	71
Cacao leaves	126	20
Coffee leaves (*Robusta*)	17	..
Coffee leaves (*Arabica*)	28	..
Rubber leaves	8	..
Tea leaves	5	..
Pueraria leaves	8	1
Centrosema leaves	5	..
Sweet potato leaves	..	4
Pumpkin leaves	1	..
Coconut waters	135	..
Total	365	96

Some of the more important investigations in this field were as follows:

Coconuts.

Analyses of soils, coconut waters, husks, fronds and cover crops have been used in the study of palm nutrition. Preliminary studies were concentrated on the potassium status of the palm, as this element is very important in coconut nutrition. A convenient method of direct flame analysis was established for potassium estimations. Sodium, calcium and magnesium are similarly determined by flame methods on the same samples as potassium. The method has been published in the following paper: " Flame spectrophotometric determination of Potassium, Sodium and Magnesium in coconut waters "—P. J. Southern: *Papua and New Guinea agric. J.* **11**, (3): 69–76 (1956) (published 1959). Limited phosphate, chloride and sulphate analyses have been carried out on nut waters.

Observations on the application of nut water analysis as a diagnostic technique have shown that the concentrations of potassium and calcium were at a maximum in the very young fruit, falling to a more or less constant level at the six to seven months or hardening stage. After the mature nut fell, the levels diminished as germination proceeded and increased when moisture loss led to a concentration of the nut water. The reduction in values as a result of germination was not significant until the diameter of the developing haustorium exceeded 1 inch. Thus coconuts collected from the lower spathes of the palm or from the ground after nutfall may be used for comparative analyses provided they are checked for the stage of germination and precautions taken against moisture loss.

Studies of the nutrient levels in fronds have been made to determine nitrogen, phosphorus, potassium and magnesium status. Variations occur with the ageing of the fronds and consecutive fronds show graduations in chemical content. As the third frond from the growing point shows large differences in nutrient levels on varying soil types, about twenty leaflets selected from the middle of this frond are taken as representative.

Frond and nut water analysis have been applied successfully to the diagnosis of coconut nutrient problems in New Ireland and elsewhere in the Territory.

New Ireland Coconut Decline.

On the coral-derived soils of the east coast of New Ireland, a serious decline in coconut health is proceeding. Soil, agronomic, entomological and pathological surveys suggested that a soil factor was probably involved and analyses showed possible deficiencies of calcium and potassium. Following a comprehensive survey, it was possible to relate low potassium levels in nut water, husks, and foliar material to the degree of decline as measured visually and in terms of productivity, and the work was published under the title " Evidence of Potassium Deficiency in Coconut Palms on Coral-derived Soils in New Ireland from Analysis of Nut Waters, Husks, Fronds and Soils"—S. C. Baseden and P. J. Southern; *Papua and New Guinea agric. J.* **11**, (4): 101–105 (1959). It was observed also that there was good correlation between the degree of chlorosis in the palms and the amount of leaf scorch in the *Pueraria* cover crop. These leaf scorch symptoms have been reproduced in pot experiments and eliminated following the addition of potassium.

Chemical analyses have been carried out in conjunction with the coconut fertilizer trials on two main soil types at Kaf Kaf and Piera. Soil analyses were carried out on all plots, and nut waters collected at six monthly intervals analysed. They indicated considerable uptake of potassium by treated palms and the maintenance of low levels in untreated palms.

Chlorosis in Coconuts.

Chlorosis is a symptom seen in palms in many parts of the Territory and appears to be caused by a wide range of unfavorable factors. Endeavours have been made to determine specific causes in different areas. In New Ireland dressings of potassium fertilizer have removed the symptoms. In the Gazelle Peninsula, destruction of the strongly competitive grass ground cover and its replacement with legumes has led to the disappearance of symptoms. Chlorotic palms in scattered areas along the north coast of the mainland and in Papua have responded to potash. In other instances, as in the Bainings region of New Britain, chemical investigations have not indicated the cause of the condition, which may in some instances be connected with waterlogging or other unfavorable physical conditions in the soil.

Rubbery Copra.

Rubbery copra is a term used to denote copra with a rubbery or leathery texture which rapidly absorbs moisture from the atmosphere, does not break cleanly and, because of the difficulty of crushing, causes milling problems. An investigation of the cause of the condition has been proceeding for several years. Statistical data compiled have shown that the defect is widespread, having been recorded on 181 plantations scattered throughout the Territory and on varying soil types subject to a wide range of climatic conditions. Rubbery copra is found most often on the south coast of Papua, east coast of New Ireland and in the Bainings region of New Britain, but may occur from time to time even on the volcanic ash soils of the Gazelle Peninsula. Produce inspection records indicate that about 5 per cent. of all consignments contain an admixture of copra with rubbery characteristics. The seriousness of the problem to individual plantations may be indicated by the fact that on one plantation producing 750 tons of copra during the year, the proportion of rubbery copra in different batches ranged from 10 to 50 per cent.

Initial investigations were aimed at correlating rubberiness with some phenotypical feature which would allow the identification in the field of palms producing rubbery copra. No significant relationship was found between rubberiness and appearance; shape or size of nuts; thickness of husk; appearance, thickness and surface features of the endosperm; or taste, odour and colour of the endosperm or nut water. Analysis of nut waters for sodium, potassium, calcium, magnesium, phosphates, and chlorides similarly yielded no significant information.

Studies of copra produced from isolated palms known to give rubbery copra indicated that degrees of rubberiness could be identified and that the moisture content of rubbery nuts was higher than normal, being highest in nuts which gave the extreme forms of the defect, where the resultant copra is shrivelled and distorted with parchment-like texture. The oil content was also found to be inversely proportional to the degree of rubberiness.

Whilst in a number of localities rubbery copra occurs in delimited areas where the palms are unthrifty and show various defects, the nutritional approach is complicated by the fact that rubberiness also occurs in areas where palms are growing on fertile volcanic soils and look healthy. In the same way, root systems have been found to be normal, the fertility of certain soils producing rubberiness confirmed by chemical analysis; and frond analysis for nitrogen, phosphorus, potassium, sodium, calcium, magnesium, iron, manganese, copper and sulphur have shown no correlation between levels of these nutrients and the condition.

Some evidence has been obtained bearing on the possibility that rubbery copra may be a genetic condition. At two plantations nuts from the same spathe on isolated palms gave copra which varied from the extreme form of rubberiness to normal; *contra*, all nuts from identified palms at a third plantation yielded rubbery copra. There was a tree-to-tree variation at this plantation in the degree of rubberiness but little or no variation between nuts from the same spathe and usually between nuts from the same tree.

On a plantation which has had constant difficulties in producing evenly-dried batches of copra, it was found that a high proportion of the palms gave copra with mildly rubbery characteristics. Examination of samples from several batches of copra showed that rubbery pieces still had 6.5 per cent. moisture content when the moisture level of the normal copra in the same batch was down to approximately 3 per cent. Even when drying of a batch was carried to this level, the rubbery copra still gave the impression that it was undercured, which could lead to its rejection.

Cacao.

Although the large scale planting of cacao is relatively new, symptoms of nutritional disorders have appeared in several areas. Micro-nutrient deficiency effects are evident in the Markham Valley and marginal leaf scorch, probably caused by potassium deficiency, is common in New Ireland. Nitrogen deficiency is suspected in certain areas, especially where cacao is interplanted with coconuts. Foliar analyses have been utilised to demonstrate potassium deficiencies in the debilitated coconut areas of New Ireland. The potassium content of cacao leaf samples exhibiting marginal scorch ranged from 0.38 to 1.06 per cent. K while the levels in symptom-free leaves ranged from 0.96 to 1.86 per cent. K. The average for 30 samples from thrifty cacao trees on the fertile volcanic ash soils of the Gazelle Peninsula was 2.55 per cent. K. Low potassium levels have been found in leaves from the Sepik and Markham River Valleys, Kar Kar Island and the Finschhafen area.

Phosphorus contents of samples from 14 sites in New Ireland ranged from 0.14 to 0.22 per cent. P compared with an average figure of 0.21 per cent. P from 30 Gazelle Peninsula samples.

Coffee.

Foliar samples were collected during the year both from lowland and highland areas. A programme is planned to determine the state of nutrition and threshold values for the crop as well as the fertility status of the coffee-producing soils. Analyses of lowland coffee leaf samples did not reveal severe deficiencies or imbalance of major nutrients. The chlorosis rather commonly observed in lowland coffee may be caused by shortage of available micro-nutrients in alkaline soils. On the other hand, analysis of highland coffee leaves has given evidence of deficiencies of major nutrients as well as micro-nutrients.

Rubber.

Pilot fertiliser trials on rubber at Sogeri, commenced in 1958, have demonstrated that significant increases in growth can be obtained by applying nitrogen to young replants under these conditions.

Tea.

An investigation of chlorotic tea at Garaina suggested that sulphur rather than nitrogen deficiency might be the main cause of chlorosis. Yellow leaves contained more nitrogen but less sulphur than healthy leaves. These results are being followed up with field trials.

General and Industrial Investigations.

Agricultural Products.

Cocoa beans.

In 1957 a comprehensive investigation of the quality of Territory cocoa beans was commenced. Two hundred and ninety six cocoa bean samples were collected from 83 producing centres during "flush" and "non-flush" periods. Bean weight, moisture content, shell percentage, fat content, the chemical constitution of the fat and some other characteristics were measured. The following facts emerged:

(i) Beans from the "flush" period were significantly heavier than from the off period.

(ii) Frequency distribution based on bean length measurements reflected the hybrid nature of the population and could be utilised to determine population uniformity. Bean weight frequency distributions were not a satisfactory measure of uniformity.

(iii) There was no significant relationship between bean weight or bean size and fat content.

(iv) Shell percentage, as the term is used in the trade, to include the testa and all attached mucilaginous material, was invariably high. It is uncertain whether the Territory population has a genetically high shell content or whether the methods of fermentation and drying are such that the amount of extraneous material dried on the testa is higher than in some other countries. Testas of different beans varied in their capacity to absorb and hold moisture.

(v) Fat content was influenced by genetical composition and the degree of fermentation.

(vi) Fat quality, as measured by the chemical constants acid value, saponification value and iodine value was similar to that of normal Accra samples.

(vii) No significant variations in quality could be related to ecological or environmental effects.

Copra.

A comprehensive investigation of sampling methods, coupled with analysis of the oil content and free fatty acid content of copra, was carried out to determine whether, and under what conditions, such analyses could be used to assess the value of copra on a commercial scale.

A grab sample was drawn from every fifty bags of each of the three grades of copra produced at the Government coconut plantation at Orangerie Bay during the three months February to April, 1959. Two hundred and ten samples representing over 1,000 bags of the three grades Hot Air, Fair Merchantable Sun-dried and Smoke were analysed for oil content. The estimates of variability between samples were quite wide, with F.M.S. and Smoke grades significantly more variable than Hot Air. Standard errors for estimates were respectively 1.134, 1.919 and 1.767.

In addition to the above investigation of the variability of copra from a plantation, a study was made of the oil content of a copra shipment. Approximately 1,800 samples of the three grades were collected from the loading of a shipment from two ports, Samarai and Rabaul. The samples were pooled by day lots in twenty sacks and after reduction in size, eight sub-samples were drawn from each sack. The method of sampling and of sample reduction enabled estimates of the oil content to be made within narrow limits of variability. Standard errors of the weighted means for the total shipment were as follows:

Total Copra—All Grades	0.100
Hot Air Grade	0.167
F.M.S. Grade	0.115
Smoke Grade	0.213

Reduction of sub-sampling intensity by halving the number of sub-samples taken was found to lead to a four-fold loss in precision.

Whilst no significance was found for each grade of copra by ports, a composite analysis over ports and copra grades indicated a significant main effect for ports, Samarai being higher than Rabaul.

Pyrethrum.

Detailed chemical assays of Pyrethrum strains developed at the Highlands Agricultural Experiment Station, Aiyura, were commenced in 1958. Thirty-eight selected strains have now been assayed for pyrethrin I and pyrethrin II and nine of these strains have been check-assayed by the London firm of Stafford Allen & Sons. This firm also carried out twenty-three Peet-Grady biological tests on three samples submitted for check analysis.

Whilst a few strains analysed had too low total pyrethrins content to be suitable for commercial production, the majority had average or better total pyrethrins content.

There is some confusion as to the most desirable ratio of pyrethrin I : pyrethrin II. According to the literature, a high ratio of pyrethrin I : pyrethrin II gives a better " knock down ", but the Peet-Grady test showed that Strain AIY84 with a total pyrethrins content of 2.0 per cent and a pyrethrin I : pyrethrin II ratio of 6.2 was less efficient in causing " knock down " than standard extracts. On the other hand, Strain AIY93 with a total pyrethrins content of 1.9 per cent. and a pyrethrin I : pyrethrin II ratio of 2.6 was as effective as standard extracts. Selection is currently based on high total pyrethrins with average pyrethrin I : pyrethrin II ratios, approaching unity.

In addition to analysis for pyrethrins content and ratio, some studies have been carried out on the relationships between pyrethrins content and ratio and the stage of development of the flower head. The results obtained have closely agreed with overseas experience and pyrethrin I : pyrethrin II ratios in average tests varied from a maximum of 1.44, in the small flower with rays vertical, to a minimum of 1.0 in the large, fully opened flower.

Pastures and Fodders.

Ten pasture samples and 60 fodder samples were analysed during the year, 26 of the latter coming from the *Crotalaria anagyroides* mowing trials at Nondugl. This trial entailed mowing at two-, four- and eight-weekly intervals at 6- and 12-in. cutting heights. Highest yields of crude protein per acre were obtained from the eight-weekly 12-in. mowing treatment. The percentage of crude protein was highest in the two-weekly cuts at 12 inches but the yield was down to half that obtained from the eight-weekly cuts.

Other fodder samples included maize silage, maize grain and cob meal, copra meal, wheat meal, peanut meal, whale meal and sweet potato tops. Pasture samples analysed included Para grass (*Brachiaria purpurescens*), Kangaroo grass (*Themeda australis*) and *Rottboellia exaltata*. The last, which is a tall grass, yielded 18.2, 13.3 and 6.5 per cent. crude protein at the pre-flowering, flowering and post-flowering stages.

Phytochemical Investigations.

Mimosine Content of Leucaena glauca.

The leguminous tree *L. glauca* is of great importance in the Territory as a shade tree especially for cacao and coffee. It also has great potential value as a pasture species as it provides green material of high protein content throughout the year and is palatable to stock. Its use as a pasture species is limited firstly by management problems and secondly by the presence of the alkaloid mimosine, which can be damaging to stock, especially horses.

The local strain has a relatively high content of mimosine but three strains with reputedly low mimosine (El Salvador, Guatemala and Peru) have been introduced to the Territory through the Commonwealth Scientific and Industrial Research Organization. These strains are established at a number of locations throughout the Territory and foliar samples have been collected for analysis, together with samples of the local strains from the same areas.

Miscellaneous Analyses.

Fifty water samples were received during the year from a number of sources and a wide range of other miscellaneous samples, varying from food materials to samples of animal origin in cases of suspected poisoning, have been studied.

SOIL SURVEY.

The Soil Survey Section is centred at Port Moresby but in the nature of the work, field investigations are carried out anywhere within the Territory. The staff position has improved so much in recent years that it was possible this year to maintain two complete parties in the field for the first time. This permitted the detailed investigation of the Wahgi Valley to be continued without interruption, while meeting demands for surveys required for land settlement purposes in other areas. The main investigations carried out during the year were as follows:

Wahgi Valley Survey.

This is the first stage in a base survey of the whole Highlands area, irrespective of land ownership, for the purpose of determining present land use and planning future development, re-settlement and other projects. The survey is now well advanced, approximately 42,000 acres being covered in detailed mapping. The most important part of the survey is the study of the extensive peat swamps in the valley with a view to determining their optimum utilization and to providing basic information of general applicability to drainage problems in the Highlands. The survey has so far made studies of soil relationships developed on the andesitic ashbeds of the Mount Hagen area and of the peaty clays and raw peats of the swampy area. In conjunction with the physical and chemical examination of the soils, a micro-plot technique, utilizing maize as a test crop, is being used as a field check on fertility and nutrient availability. All soils tested have responded markedly to phosphorus but have not shown other obvious deficiencies and are of moderate fertility. The response of maize to phosphorus would not necessarily be duplicated in a crop such as coffee which is tolerant of a relatively low phosphate status.

In the course of this survey, detailed soil maps of all coffee plantations established in the area are being prepared with the intention of maintaining, in co-operation with Agricultural Extension officers, a record of the cultural practices adopted by individual planters, with a view to interpreting long-term production and other trends which may appear.

Mori and Bamguina.

This survey was made for the purpose of subdivision. The area had previously been delineated, in a reconnaissance survey carried out in 1955–56, as the most promising part of a large area of Crown land. The detailed survey covered an area of 29,845 acres between Mori and Bamguina Rivers in the Abau Sub-district—27 units were used to map this land. Some 8,000 acres were found to have very limited economic potential because of extreme stoniness, steepness or poor drainage, while a further 2,250 acres consisted of heavy-textured grey clay loams subject to flooding and with a potential for flooded rice culture only. The remainder of the area had generally good agricultural topography with soils derived from recent alluvium and usually of good physical structure. Chemical analyses, however, indicated that the soils limit the range of tree crops which could be grown satisfactorily; cacao would not thrive and only coconuts and rubber could be recommended. Peanuts and other annual crops might be considered. A significant area of acid red clay was found in the extreme north of the surveyed area.

West Kuriva.

A detailed survey was made of 3,190 acres of land situated in the Central District between Kuriva and Veimarai Rivers. This area was investigated with a view to assessing its potential for Native settlement on relatively small blocks. There were 400 acres of recent alluvium with generally good agricultural characteristics and 2,200 acres of undulating country developed from basalt and characterised in the main by a high degree of stoniness. The latter soils could be considered only as marginal for tree cropping. The residue of the block was swampy.

Sowom Land.

An area of 2,445 acres was investigated in detail in the vicinity of Sowom in the Sepik District, again with a view to assessing the potential for Native settlement. The area is part of a coastal alluvial plain. 1,074 acres had an immediate potential for cropping while an additional 536 acres had a moderate to low potential, limited mainly by poor drainage. The remaining area was swampy. The principal chemical characteristics of the soils were the very low phosphate status and a low exchangeable potassium status which would be further aggravated by the high calcium and magnesium contents. These characteristics would limit the cropping potential mainly to coconuts and food crops.

Vudal Agricultural College.

A detailed survey was made of the 600 acres set aside for the Vudal Agricultural College and a map of the area was prepared. The aim of the survey was to provide information necessary for planning the lay-out and development of the College buildings, grounds and farming areas.

Investigations of Individual Blocks.

Marshall Lagoon.

Two areas were studied, one of 815 acres on the Lakao River, comprising 440 acres of deep light-textured alluvials suitable for all plantation crops, 120 acres of lateritic soils carrying savannah vegetation and 225 acres of grassland and swamp. The second area, in the same vicinity, consisted of two blocks of 1,016 acres and 720 acres. Both blocks could be divided into forest, savannah and grassland areas. Soils varied from light-textured loams to heavy-textured clay loams, and clay developed from alluvium. In common with other alluvial soils on the coast of Papua they were neutral to alkaline in reaction and base-saturated, with a consequent limitation on the range of tree crops which could be grown.

Kosipi.

This block of 476 acres is situated in the Goilala District at an altitude of 6,300 feet. The topography runs from river flats and swamps up to foothill country. The soils were relatively uniform, being derived from sandstone parent material and characterised by a peat layer at depth.

Musgrave River Area.

Two blocks, together comprising 2,275 acres, were inspected with a view to determining their suitability for rubber growing. Most of the area consisted of steep ridges with slopes in the order of 25 to 40 degrees and with numerous rock outcrops. Seven hundred acres of moderately sloping land was delineated and considered suitable for rubber growing, provided planting practices to minimize soil erosion were undertaken.

Talasea.

Seven areas totalling 10,789 acres were the subject of a reconnaissance survey to determine their suitability for resettlement purposes in general terms and also to decide what additional investigations would be required prior to subdivision. All areas are on pumice soils but several blocks situated at the base of mountains had very coarse profiles. Under these circumstances, water relations might prove to be a limiting factor in the establishment of tree crops. With the further reservation that poorly drained areas occur within some blocks, the whole of the survey area appeared to be generally suitable for tree cropping.

Spot Investigations.

In addition to the work listed above, spot investigations were carried out as required in connexion with land purchase, development, and soil problems.

DIVISION OF EXTENSION AND MARKETING.

In pursuing the objectives previously outlined, the Division of Extension and Marketing, which has its headquarters in Port Moresby, operates through its Regional and District Agricultural Officers, together with their staffs of Agricultural Officers in districts and sub-districts, and indigenous Assistant Agricultural Officers and Fieldworkers. The Regional and District Agricultural Officers have the responsibility for organizing all aspects of extension and marketing with European and indigenous farmers whereas the lower level intermediaries operate entirely with indigenous agriculturalists.

Some discussion of indigenous agriculture is necessary as a background to the activities of the Division.

PRINCIPAL TYPES AND METHODS OF INDIGENOUS AGRICULTURE.

Agricultural production is predominant in the economic life of the people; as well as being responsible for a large proportion of the Territory's export income, it provides the vast majority of the indigenous inhabitants with their subsistence requirements and the basic income needed for their economic advancement.

The main forms of agriculture practised in the Territory are:

(i) Subsistence farming based on bush and grassland fallowing and the production of root crops as a staple, supplemented by such minor crops as maize, beans and various types of fruit and vegetables.

(ii) The production of dual-purpose crops (e.g., peanuts and rice) which play a part both as subsistence foods and cash crops, allied with the cash sale of surpluses of the traditional subsistence crops such as bananas, sweet potato, taro and yams.

(iii) The plantation production of such perennial crops as coconuts, cacao and coffee for export. Although in the past the production of plantation-type crops has been in the hands of non-indigenous producers, there has, as a result of Agricultural Extension programmes, been a very rapid growth of indigenous participation in these industries in recent years. Indigenous cultivators now control more than half the acreage planted to coffee and are progressing towards having more than half the production potential in the commercial coconut industry. Many of the plantings are as yet immature, and it will be some years before the planting position is actually expressed in terms of production.

CULTIVATION METHODS AND TECHNIQUES OF THE INDIGENES.

Although indigenous farmers are developing new skills and are increasingly undertaking the specialized production of particular crops as a means of raising their living standards, subsistence production is regarded as the economic sheet anchor and will mitigate the effects of any difficulties they may encounter in particular forms of activity during the period of transition.

There are many ways in which productive efficiency can be increased by the modification of existing techniques, but because of the variations in climate and the generally broken nature of the terrain over the whole of the Territory, a degree of caution must be exercised in introducing changes, so that active destruction of agricultural resources may be avoided. The Administration therefore maintains a close and continuous survey of agricultural conditions

among farmers, and designs its Extension programmes in such a way as to bring about an evolutionary development of indigenous agriculture based on the valuable and conservational aspects of the existing system. For example, the present basic system of bush or grass fallowing, whilst inefficient in that it requires a major clearing effort each time a crop is planted, is conservational in that the re-growth which takes place in gardens tends to preserve the soil from physical and chemical degradation. Extension programmes aim at showing farmers that they can considerably decrease the labour connected with producing their food requirements by practising a rotation on each clearing before it is abandoned, instead of the older method of taking only one crop before land reverts to bush or grass fallow. It has been found that soil fertility is far from being the only factor governing traditional agricultural practice and that other difficulties, such as build-up in the incidence of pests and diseases, combine to make successive cropping with a single staple impracticable. The lack of foods suitable for storage makes the indigenes dependent on day-to-day harvesting of the perishable staples and subject to the effects of seasonal variations. Rice and peanuts yield foods which can be stored and fit in well with traditional subsistence methods; farmers are encouraged to expand the production of these crops. Use is encouraged of leguminous covers or quick-growing leguminous trees, which provide only a minor clearing problem, as a substitute for the natural rejuvenation of soil in the bush fallow by natural forest growth. It is not yet known exactly to what extent a complete resting period for soils can be deferred.

The production of staple foodstuffs is usually closely interwoven with the social structure and religious beliefs and practices of indigenous communities. Tastes, prejudices, fear of contamination of themselves and of their agricultural land, and the fear of relying on crops with which they are unfamiliar, are all difficulties which are met with in attempting to diversify and improve the efficiency of agriculture. Training programmes in which cultivators are given specific instruction in new methods, and shown the value of new and varied foods, accelerate their adoption by the people.

The expansion of perennial crop planting, particularly for cash cropping, introduces specific problems. Perennial crops are of minor importance in the primitive subsistence economy; land tenure systems correspond with the land use methods for the production of the annual staples and land ownership is of little importance in relation to the location of groves of perennials. However, when perennials are used for cash cropping, particularly where formal spacing and techniques other than grove planting are adopted, the attitude to the land involved tends to change radically. For example, where land under tribal conditions changes hands through matrilineal inheritance patterns, men growing perennial crops develop the wish to hand it down through their own lineage. Perennial cash crops have now become an important factor in the economy of many indigenous rural communities in the Territory; this form of planting appears to integrate best with tribal subsistence agriculture, when individual plantings are made within the boundaries of land owned by the social group to which the cultivator belongs. Such plantings also have a stabilizing effect on tribal tenure, since groups resist the surrender of such an asset when land is being exchanged during marriage transactions, or for similar social reasons. Difficulties will be encountered also in the extension into the indigenous system of mechanized production of annual crops, since, to be profitable, mechanized production requires substantial units of land which can be subjected to uniform cultivation procedures. The ultimate solution to these problems is undoubtedly the rationalization of tribal tenure so that the farmer can be issued with a legal title to replace his tribal right, and the principles to be followed in achieving such a rationalization have been defined.

However, indigenous communities are extremely cautious towards any suggestion of replacing traditional tenure and, in the interim period, new systems of planting can be introduced side by side with subsistence production provided there is not a widespread development of permissive occupancy planting outside the land boundaries of effective social units.

A primitive but highly developed system of agriculture which includes the composting of vegetable matter is practised by the Enga people in Wabag Sub-district. Saucer-shaped depressions are filled with vegetable refuse which is heaped up and covered with fine top soil, making a compost pit. Sweet potato, the local staple food, is planted in this pit. This system offsets the rather poor soil conditions and the warmth generated by the further decomposition of the compost counteracts the effect of the severe cold of the high altitudes.

Another specialized development in traditional land-use practice, which has been revealed by surveys by Agricultural Extension officers, is the division of garden land into square beds by a lattice of deep trenches. The sub-soil from the bottom of these trenches is thrown up on top of the beds and mixed with the topsoil before planting. This practice is used in the Wahgi Valley. Agricultural Extension officers encourage extension of the use of such beneficial traditional methods in all areas where they increase productivity on poor soils and there has

been a notable expansion of their use in Western Highlands District. With the introduction of coffee as a cash crop, it has been found that farmers are quite willing to accept the principle of mulching because of their past experience of closely allied practices.

In the drier areas of the Eastern Highlands, irrigation is becoming a more common practice as a means of coping with drought problems and resultant food shortages. The matter of ensuring continued food supplies in the frost areas of the Highlands continues to receive attention. Good results have been obtained from the partly frost-tolerant European potato variety introduced for this purpose. Planting material from early harvestings of this variety has been widely distributed in the Highlands districts.

In the Chimbu sub-district much of the land under cultivation is on hill slopes. The clearing of forest from these areas has led to erosion by wash and landslides and, in some cases, has tended to destroy catchment areas. The sub-district has been provided with a specially selected team of Agricultural Officers, and survey work aimed at assessing the land use situation has been continued. Surveys conducted to date show that there is no immediate shortage of land at the present level of production, with the majority of farmers still practising subsistence agriculture, and that overall there are substantial reserves of available land. These surveys have, however, identified the Upper Chimbu Valley area, which has about 10 per cent. of the sub-district population, as one where problems of land shortage will develop at an early stage of economic expansion. The position of this area is being kept under close examination by agricultural patrols to ensure an early awareness of any need which may arise for resettlement.

In areas where major deterioration of soil and vegetation has resulted from the application of primitive land use methods, particularly from burning for hunting in lower rainfall regions, Agricultural Extension programmes include measures for land reclamation and conservation. A major programme of this type is at present being undertaken in the Eastern Highlands District, the lines of action being the control of burning, including the prosecution of offenders, the encouragement of the people to refrain from cultivating ridge top and watershed areas, and a programme, supported by the supply of suitable tree seedlings, for the recovery of degraded grassland country by reforestation. The programme, which is approved by the farming population, is resulting in natural regeneration of vegetation throughout extensive degraded and eroded areas, and fairly dense stands of young secondary forests are now appearing in some of these areas. There has been a change in emphasis involving the expansion of planting of *Casuarina* species as it has become obvious that this genus is the most widely adapted to land improvement work over a range of soil and climatic types in the highland areas. The planting of Casuarinas on old garden land and degraded grasslands has become established as an accepted technique.

STATUS OF INDIGENOUS AGRICULTURE.

In recent years active and expanding Extension programmes have had a noticeable influence on indigenous agriculture and changes in its status are now becoming apparent. Since about 1956, a noticeable change has been the increasing diversification of subsistence and cash cropping.

A marked expansion of the area and output of individual farms is also taking place, and a greater understanding of the relationship between increased volume of production and increased income is becoming apparent. In the past, the areas cultivated by individual farmers tended to show little expansion even when new crops were introduced and when larger blocks of particular crops were achieved by co-operative effort, the area planted or cultivated per farmer did not increase.

A survey of the status of indigenous agriculture in the Territory (through which a constant review of the position is maintained) has been instituted. This has so far shown that, particularly in New Britain district with cocoa and in Eastern Highlands district with coffee, there has been an expansion in the size of blocks cultivated by indigenous farmers, while there has been a similar expansion in association with the mechanized production of annual crops in the Markham Valley area of Morobe District. Important developments during the year under review have been the introduction of cattle husbandry into indigenous land-use in the Eastern Highlands and Morobe districts, and the development of individual farms completely outside the tribal agricultural system in New Britain district. In the latter case, the farmers have taken up their blocks on Administration-owned land and have been granted formal tenure in the form of a leasehold title. Work on the development of new commercial crops suitable for indigenous farmers is continuing and during the year under review further advances were made with indigenous production of castor-seed in the Sepik District and tobacco in Eastern Highlands and Madang Districts.

DEVELOPMENT OF INDIGENOUS AGRICULTURE.

It is the policy of the Extension services to study the particular needs, opportunities and problems of each district in which it works and to draw up programmes of Extension work suitable to each particular district, bearing in mind that change can be effective only if it is introduced gradually and is accepted voluntarily by the people. The programmes are kept continually under review and are adjusted to meet changing circumstances.

With present levels of social and educational advancement, it is impossible for the great bulk of the indigenous farming community to conceive of land use procedures as rational systems, or to have a conception of anything like a national or territorial aim of preserving total agricultural resources through sound and conservational methods. Consultation with the indigenous population is a necessity, but can at present be expected to have no more than a local application. It will, for some years, be necessary for the Administration to accept all of the responsibility for conserving resources.

Further favorable progress was made in all districts during the year with the implementation of development plans for indigenous agriculture. Proposals were approved during the year for a major intensification of Agricultural Extension work aimed at fostering such development. Progress in individual districts is reported below.

Sepik District.

There was a further shift in emphasis from the unsatisfactory cacao plantings reported in previous years to robusta coffee growing both in coastal and inland foothill areas and the first small commercial crops of coffee from indigenous farmers were satisfactorily marketed.

Further plantings of coconuts, totalling 25,000 palms, were made in coastal and riverine areas, bringing the total of new plantings of this crop in recent years to 305,000 palms. At the same time copra production by indigenes showed a sharp improvement from 250 tons in the previous year to 570 tons.

The Agricultural Extension programme has been further intensified in the inundated areas of the valley of the Sepik River and its main tributaries the Keram and Yerat, the emphasis being on copra and rice production.

Owing to adverse marketing conditions, commercial peanut production declined to 180 tons. However, the use of this crop for local food supplies expanded further.

Madang District.

Copra production remained steady, but there were further new plantings of coconuts, bringing the total of newly planted palms not yet in bearing to 405,000, which allows for a considerable expansion in production in future years.

Planting of cacao continued in selected suitable localities, with the main centre at Kar Kar Island, bringing the total of trees to 126,000. Cocoa production was 20 tons, many trees being still immature.

Rice production continued steady in the face of adverse marketing conditions with an output of about 250 tons. Standards of production in the industry, which is centred in Madang Central sub-district, show continued improvement.

Arabica coffee culture is developing in the Finisterre Ranges in Saidor sub-district and small plantings of robusta coffee are being made in isolated coastal localities. There has been some initial commercial production of tobacco in the Finisterres for sale to a factory established at Madang.

Morobe District.

A major coffee industry in the hands of indigenous farmers has now been developed in mountain areas of this district, with plantings reaching a total of 2,000,000 to 3,000,000 trees of arabica, and the largest centre of planting located in the mountainous hinterland of Finschhafen sub-district. In addition, 20,000 robusta coffee trees have been planted in coastal areas. Coffee production increased to 227 tons.

Further attention was given to the coconut industry and copra production increased to 350 tons.

The development of indigenous mechanized farming in the level areas of the Markham Valley continued and these growers, besides producing 69 tons of peanuts, have become the major suppliers of truck crops to the town of Lae.

Major developments in rural organization and marketing took place in the district during the year, with the formation of the Finschhafen Marketing and Development Society and smaller organizations on the Rural Progress Society pattern at Morobe and Bukaua.

Manus District.

Young coconut plantings were increased to 54,000 and copra production was 437 tons. Cacao plantings increased to 14,000 trees and coffee to 5,000 trees.

Continued attention was given to annual food crops both for subsistence and cash sale, and truck crop output rose to 180 tons.

New Ireland District.

An additional 55,000 seedling coconuts were planted bringing the total of young palms from recent programmes to 290,000. Copra production for the year was steady at about 5,500 tons.

Only limited localities are suited to cacao and planting in these has at present reached capacity at about 70,000 trees. Production of cocoa beans for the year rose to 53 tons.

Plantings of robusta coffee increased to 18,500 trees while small plantings of arabica were initiated in mountainous inland areas. As all coffee is still immature, there is no production.

Attention to the improvement of subsistence was continued with sweet potato and peanuts gaining ground as subsistence crops.

New Britain District.

The total census of indigenous-owned coconuts is nearing completion and indications are that 4,000,000 palms, equivalent to 80,000 acres of coconuts, have been planted. Of the total figure, some 700,000 palms are not yet in bearing. A proportion of the production is used for domestic food purposes. These figures reflect very large planting programmes of recent years and planting is now slackening. However, there is established a potential for increased production well beyond the present level of 10,000 tons.

The District is at present the major source of indigenous cocoa production which continued to rise from 1,150 tons in 1958–59 to 1,450 tons in 1959–60, while plantings increased by 331,000 trees to almost 3,000,000.

Small quantitites of robusta coffee have been planted in the southern areas of the district in poorer soils or where the population is too light to provide a satisfactory volume of cocoa for processing purposes.

Resettlement schemes have been initiated in the Keravat and Warangoi Valleys for advanced farmers, mainly from the Gazelle Peninsula area. An Extension Officer has been allotted on full-time duty to cater for the needs of these settlers.

Annual crop production continued to receive attention. Supplies of truck crops to Rabaul were maintained at 1,500 tons while a small commercial output of peanuts was noted in the Nakanai area of Talasea sub-district.

Bougainville District.

Copra production continued at the 1958–59 level of almost 2,000 tons, while an additional 22,000 seedling palms were added to new plantings.

The district is the second largest cocoa producer after New Britain and plantings by indigenes further increased to 265,000 trees. Production is still low as most trees are immature.

Continued attention was given to the isolated southern areas of Bougainville where the Rural Progress Society movement gained further ground, with three societies operating in the Buin area and one in Kieta sub-district. Adverse marketing conditions caused a fall in peanut production in these areas to 70 tons but rice production was maintained and further plantings of cacao and robusta coffee were made, in the interests of diversification. Robusta coffee plantings now total 25,000 trees.

Eastern Highlands District.

The major development with arabica coffee by indigenes in this district continued with recorded plantings reaching 2,000,000 trees. Production of green coffee increased to 300 tons.

The programme to establish commercial peanut growing by indigenes on a sounder basis met with success and 52 tons of high grade kernels were marketed. Attention is also being given to the building up of local food industries with the emphasis on peanuts, maize and sunflowers, while truck cropping with roots was maintained at a steady level.

PLATE 18—*New Guinean tobacco growers carefully grade the leaf before sale.*
[Photograph Division of Extension Services]

PLATE 19—*An Agricultural Officer demonstrates techniques to New Guinean cacao growers.*
[Photograph Australian News and Information Bureau]

Passionfruit production from this district and Western Highlands at present supplies the whole market requirements, the district contribution during 1959–60 being approximately 1,000,000 pounds of raw fruit delivered to the processing factory at Goroka.

Tobacco production by indigenes was initiated in the dry belt section of the district near Bena Bena, and a crop of 12 acres resulted in the production and sale of 3 tons of leaf. Plate 18 shows indigenes sorting cured leaf.

Also in the Bena Bena locality, cattle were introduced into the land-use system of indigenous farmers, a number of the latter being supplied with cows either with calves at heel or carrying calves. These were selected beasts supplied from Administration livestock stations. Further indication of the emphasis being placed on improved animal husbandry was the sale of improved sows to a number of farmers and the establishment at various centres of stud boars available for serving farmers' sows.

Western Highlands District.

The pattern of development here is similar to that in Eastern Highlands, but owing to greater remoteness and later contact, this district is not so far advanced although undergoing rapid expansion. The main features in 1959–60 were:

(i) An increase in arabica coffee plantings to 200,000 trees and a rise in production of green coffee to 35 tons.

(ii) An increase in passionfruit production to 400,000 lb. weight of fruit.

(iii) Maintenance of peanut production at about 20 tons and increase in truck crop production to 3,500 tons.

(iv) Surveys to prepare for the initiation of indigenous cattle ownership as in the Eastern Highlands.

AGRICULTURAL PATROLS AND VILLAGE CONTACTS.

A major expansion of this work is envisaged. The year 1959–60 saw a 100 per cent. expansion in this activity with 439 patrols resulting in 4,721 days in the field by professional officers and 53,452 days by trained Native assistants. These patrols contacted a total population of 527,000 in rural communities as follows:

District.	Approximate agricultural population contacted.
New Britain	31,000
New Ireland	8,000
Bougainville	25,000
Manus	5,000
Sepik	62,000
Madang	48,000
Morobe	150,000
Eastern Highlands	140,000
Western Highlands	58,000
Total	527,000

Areas which gained particularly from more intensive contact during the year were:

New Britain	Nakanai area—coconuts and cacao development.
Madang	Saidor, Bogia and Kar Kar—coconuts, cacao and robusta coffee.
Eastern Highlands	Fore and Pagaria and Chimbu—coffee and peanut development and census activity.
Morobe	Adzera and Finisterre ranges and Kaiapit area—coffee and peanut development.
Northern	District generally—cacao and coffee.
Sepik	Sepik River—rice and coconuts.

Plate 19 shows an Agricultural Officer carrying out Extension duties.

AGRICULTURAL TRAINING.

Approved proposals envisage training at three levels:

(i) Full diploma courses to be given at a College on a 700-acre site at Vudal near Keravat in New Britain district. These courses will be provided for students who have successfully attained the Intermediate level in academic studies.

(ii) Sub-diploma courses for students with qualifications below the Intermediate level who desire a specialized training in agriculture. It is proposed to develop the Agricultural Extension Station at Popondetta into an institution for this purpose.

(iii) Farmer training courses of nine to twelve months' duration to be given at Agricultural Extension Stations, and as field training to small groups at Extension centres. Full training facilities have been completed at the Madang Extension Station and at the Taliligap (New Britain district) Extension centre and are in course of erection at Bainyik (Sepik district) Extension Station, while temporary facilities are in use at the Extension Stations at Mount Hagen (Western Highlands), Sohano (Bougainville), Kavieng (New Ireland), and Goroka (Eastern Highlands). The number of trainees increased to 580 during 1959–60.

Until the diploma and sub-diploma courses mentioned above are established, higher level training is provided for 25 students per year at a temporary training centre at Mageri near Port Moresby. Plate 20 shows students in class at Mageri.

AGRICULTURAL EXTENSION STATIONS.

These stations serve as a district or regional base for Agricultural Extension activities and combine the functions of static demonstration, farmer training, local experimentation and seed production. It is proposed to develop fully stations located at Bainyik (Sepik district), Madang (Madang district), Korn Farm (Western Highlands district), Goroka (Eastern Highlands district), Sohano (Bougainville district) and Kavieng (New Ireland district) for the exercise of these functions.

During the year, the stations at Bainyik, Madang, Korn Farm, Sohano and Goroka continued to provide all the services outlined above. Full-scale farmer training facilities were completed at Madang station and were in the course of construction at Bainyik. Temporary facilities were in use at Korn Farm, Goroka and Sohano. A new Extension station was successfully established at Kavieng in New Ireland district and farmer training commenced with temporary facilities.

AGRICULTURAL EXTENSION CENTRES.

These centres are small establishments which serve as local bases at the sub-district or area level for field Extension activities including patrolling, rural organization and marketing assistance, field training and seed and planting material distribution. It is proposed to develop a series of additional Extension centres in all districts of the Territory to expand the services available to Native farmers from resident Agricultural Extension officers and trained indigenous operators.

During 1959–60, Extension work was continued from the following established centres:—Taliligap, Talasea and Kandrian in New Britain district; Wewak, Aitape, Yangoru and Angoram in Sepik district; Lae, Wau, Kaiapit, Finschhafen and Pindiu in Morobe district; Kundiawa, Chuave, Henganofi and Kainantu in Eastern Highlands district; Bogia and Saidor in Madang district; Konga and Kieta in Bougainville district; Lorengau in Manus district; and Minj in Western Highlands district. Over the same period new centres were established at Okapa and Onamuga in Eastern Highlands district, Wabag in Western Highlands district, and Kar Kar in Madang district.

DEVELOPMENT OF RURAL ORGANIZATION AND MARKETING.

To provide adequately for the considerable expansion of commercial production now taking place throughout the Territory, it is proposed that a series of major marketing projects will be organized on an area basis in various districts. A special marketing section within the Extension Division will provide processing and marketing facilities for indigenous producers. The projects envisaged will be organized in such a way as to integrate the work on rural

PLATE 20—*A botany class at the Mageri Training School.*
[Photograph Division of Extension Services]

PLATE 21—*A typical Native cacao fermentary in the Gazelle Peninsula.*
[Photograph Australian News and Information Bureau]

organization and marketing with such organizations as Rural Progress Societies, Co-operative and Local Government Councils, and to allow the development of individual enterprises by the indigenes within their framework. Three such projects are established and operating as follows:

Finschhafen Project.

This project is based on the operations of the Finschhafen Marketing and Development Society which was placed on a firm footing during 1959–60. The Society is organized on Co-operative lines with membership drawn from all sections of Finschhafen sub-district, and supplies marketing services throughout the sub-district, including sea-transport for coffee and copra. It is also operating a wholesale distribution service for consumer goods. Within the framework afforded by the Society, individual enterprise is developing at the village level in fields such as coffee pulping and copra drying. Extension officers make frequent use of the Society structure for contacts with rural producers, while a Project Manager has been supplied for full-time assistance to the management of the Society in organizing the purchasing, storage and transport of crops.

Inland Sepik Project.

This project embraces the activities of the four Rural Societies organized in the inland foothill areas on the northern side of the Sepik Valley. A Project Manager is located at the Bainyik Agricultural Extension Station for continuous assistance to these societies, and a central rice mill is established at the same Station to process paddy rice marketed by them. During 1959–60 the societies marketed over 100 tons of rice and smaller quantities of peanuts, while the marketing of robusta coffee is expected to be included in the project in the near future.

Tolai Cocoa Project.

This project involves the operation by Local Government Councils in the Gazelle Peninsula area of New Britain of central fermentaries for the processing and marketing of the crop from the very large cacao plantings in the area. Sixteen fermentaries are now established and processed over 1,000 tons of cocoa in 1959–60. Two Project Managers are supplied for full-time assistance with this project. A typical fermentary is shown in Plate 21.

Continuous attention was given during the year to other aspects of rural organization and marketing work, including assistance to Rural Progress Societies, Co-operatives and Local Government Councils and the provision of direct crop-purchasing facilities by Extension Officers where there are no other suitable marketing arrangements. It is expected that many of these activities will be included in area projects of the type mentioned above in future years. Brief reference may be made to the following:

Rural Progress Societies.

The four coastal Societies in Sepik District continued to operate with a turnover of 200 tons of copra and 50 tons of peanuts. An association of the four coastal and four inland Societies was formed during the year and the services of a full-time Co-operative officer were obtained. In the Madang district, the number of Societies operating increased to six. Rice is the main product marketed and the turnover was 150 tons. In Morobe district the Bangalam Society continued to engage in the processing and marketing of rice, while two new Societies engaged in copra and cocoa marketing were formed at Morobe and Bukaua. Four Societies are operating in South Bougainville, one at Kieta and three in Buin Sub-district. The Kieta Society is engaged in cocoa marketing while those in Buin sub-district engage in marketing rice, peanuts, copra and basket-ware.

Co-operative Societies.

The main activity of these Societies in relation to primary production is copra marketing and continued assistance was provided in the form of training and advice in all areas of the Territory where they operate. Plate 22 shows New Guineans loading their copra on to a Co-operative truck.

Local Government Organization.

The Division of Extension and Marketing continued to maintain a close liaison with Local Government Councils on matters affecting development of the rural economy. During 1959–60 particularly, valuable assistance was given by Councils in the Eastern Highlands in organizing field days for demonstrations of production techniques for peanuts and coffee.

OTHER SERVICES PROVIDED BY THE DIVISION OF EXTENSION AND MARKETING.

Central Processing Facilities.

The operation of the processing facilities continued; these included coffee-hulling centres at Mount Hagen, Goroka and Lae, a rice-milling centre at Bainyik (Sepik District) and a peanut hullery at Goroka.

Crop Programme.

A very important development during the year has been the initiation of a Native rubber production project at Kerema. The Administration plantation at Cupola has been subdivided and leased to villagers from the Kerema Bay area on a tapping licence basis. The Division is providing central factory facilities under supervision of a Project Manager for the purchase of latex from the licencees and also from a planting on the nearby Native land of the Ipisi group. Considerable interest has been aroused and additional Native-owned land is being prepared for planting. Additional trade-buying channels have been arranged for Native sales of latex in the Northern District and this has aroused interest in the possibility of expanding plantings, particularly in the Kokoda area.

Direct Purchase of Cash Crops.

In areas where marketing facilities are either non-existent or ineffectual, direct assistance was given to indigenous farmers in the form of purchase of their crops by Extension officers. During 1959–60, £57,000 worth of crops was purchased in this way including copra, cocoa, coffee, rice, peanuts, castor bean, tobacco, potatoes and vegetables. This service provided a particular stimulus for producers in isolated and backward areas. The keen interest of producers is obvious in Plate 23, where an Agricultural Officer is assessing the quality of coffee prior to purchase.

Machinery Section.

The Machinery Section staff consists of a Senior Mechanical Equipment Inspector at Headquarters and Mechanical Equipment Inspectors at Lae and Rabaul, together with Area chanics at appropriate points throughout the Territory to service agricultural machinery mechanized equipment for the Department, and, where appropriate, for other Departments and outside bodies. As well as routine servicing, the Machinery Section undertakes installations of machinery connected with agricultural processes. The more important installations undertaken in 1959–60 were:

(i) Installation of rubber machinery at Cupola in the Kerema Sub-district.

(ii) Installation of engine and rice mill at Turiboiru in the Buin Sub-district.

(iii) Installation of rice polisher at the Bainyik Central Mill, Sepik District.

(iv) Installation of a temporary high volume parchment coffee mill at Lae.

(v) Installation of cattle weighbridges at the livestock stations at Erap and Moitaka.

(vi) Installations of a central processing mill for rice and peanuts at Wewak in the Sepik District.

(vii) Assistance with the installation of peanut processing machinery at Kieta in the Bougainville District.

Technical Surveys and Investigations.

Regular inspections were made of all Departmental machinery and installations and installations and mechanical plant census returns furnished.

Investigational surveys were made of most of the coffee factories in the Territory. Much valuable documentary information was obtained on trends in coffee machinery installations and processing techniques. Particular emphasis was placed on methods of coffee grading.

Similar surveys were made of hot air cocoa drying in the Gazelle Peninsula, New Britain. Drying trials were carried out with one new type of hot air cocoa dryer.

Machinery for peanut harvesting, hulling and grading was investigated in the Markham Valley and at centres in the Highlands, Bougainville and Sepik.

A series of trials with oil-fired hot-air copra drying was commenced at Baibara Plantation.

PLATE 22—*Co-operative Society trucks carry members' copra to a shipping point.*
[Photograph Australian News and Information Bureau]

and

PLATE 23—*The price paid for parchment coffee depends on the Agricultural Officer's assessment of quality.*
[Photograph Australian News and Information Bureau]

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Assistance to Various Groups.

It has been the policy of the Department to assist, guide and encourage any individual or group whose activities further the agricultural development of the Territory. Accordingly the services of the Machinery Section have been available in an advisory capacity both to Native and European producers.

This assistance took various forms and was in the main along the lines indicated in the following examples:

(i) Technical advice on purchase and maintenance of machinery to Administration-sponsored Native Co-operatives throughout Papua-New Guinea. This assistance also included the repair of tractors and machinery.

(ii) Supervision of farm machinery management in respect of individual Native farmers practising mechanised farming in the Markham Valley.

(iii) Supervision and maintenance of machinery and vehicles operated by Rural Progress Societies in the Sepik District.

(iv) Maintenance of processing machinery and tractors operated by Rural Progress Societies in the Bougainville District.

(v) Installation and repair of machinery connected with the Tolai Cocoa Project in the Gazelle Peninsula.

(vi) Supervision and maintenance of tractors and agricultural machinery operated by Native contractors in the Mekeo area, Papua.

(vii) Servicing and repair of rice milling machinery operated by the Bangalum Rural Progress Society in the Morobe District.

(viii) Assistance to European producers in various parts of the Territory through the supply of information and advisory visits to farms and plantations.

Assistance to Other Departments.

Assistance to other Departments was both of an advisory nature and in the form of practical services, e.g.:

(i) Complete servicing and maintenance of motor vehicles for all Departments in the Maprik Sub-district at Bainyik Area Workshop.

(ii) Similar but irregular advice and assistance in the Buin Sub-district, Bougai

(iii) Maintenance and repair of machinery operated by the Public Works Department in the Maprik Sub-district and in the Buin Sub-district.

PRODUCTION INSPECTION SERVICES.

All copra for export is inspected at Port Moresby, Samarai, Lae, Madang, Lorengau, Kavieng, Rabaul, Kabakaul, and also in the Bougainville District as necessary. During 1959–60, inspection of export cocoa was instituted at all major ports.

DIVISION OF FISHERIES.

The Division of Fisheries commenced operations in the Territory of Papua-New Guinea in 1954 and since then has made steady progress in extending the use of modern net materials and new fishing techniques.

During the year ending 30th June, 1960, an extensive programme of fisheries' investigations has been undertaken using the two fishery ships F.R.V. " Tagula " and M.V. " Diama ". In addition two other Administration ships M.V. " Koro " and M.V. " Eros " were used for short periods and chartered vessels " Cutty Sark ", " Diari " and " Kae " were also used for varying periods, usually not longer than five to ten days in one survey.

MARINE FISHERIES.

Investigations into marine fisheries have followed two definite patterns. One is the investigation of species: surveys have extended over a wide area, exploring many types of waters for the specific purpose of locating commercial quantities of barramundi, Spanish mackerel, mullet, &c.

The barramundi surveys have extended from Marshall Lagoon to Daru and the results obtained show that it is in the Western District that the greatest quantities will be taken. These western fishing grounds are far from a central market and will involve much greater

problems in transportation than the more limited fishing areas near Port Moresby. In Marshall Lagoon it was found that the fish were spawning at the entrance to the Lagoon on an open sea beach in February, and that fish under these conditions could be taken with relatively light nets which could be quite cheap and within the financial means of Papuans in the area. In another aspect of the investigation, fish in the Laloki River near Port Moresby were found to be of rather poor quality during the dry season when the river is low and the movements of the fish are evidently limited to the small, relatively stagnant pools. In the Western District the barramundi runs at times are considerable and a fish trap under construction has a potential in the north-west season of several hundred pounds of fish per day. This would more than meet the local requirements, and a series of similar traps erected according to the Queensland State Fishing Regulations could supply a sufficient quantity of barramundi in the north-west season to warrant the use of a special fish carrier. A previous experiment with a fish trap in Bootless Bay near Port Moresby gave irregular results, mainly because of the relatively small rise and fall in tide. The fish catch was small and damage by sharks and crocodiles made the operation unprofitable.

The second main line of investigation is concerned with improvement of fishing methods. Some native fish traps have been investigated and tested and there appears to be considerable room for improvement. However, the fishermen operating small traps are usually acting as individuals and to change native custom in this regard is not always easy. The Malayan-type prawn trap has possibilities on the Coast and in the Sepik River; although the results up to the present time have been inconclusive, further experiments are in hand.

"Tagula" Operations.

During the year "Tagula" operated for about 150 days fishing at sea. This small operating time was caused, in part, by the three changes in command and special leave for one Master to visit Australia. During a period of six weeks, the vessel was laid up (because of the absence of the Master) and at a later date refitting took place over a period of four months. Also during this period, a new trawl winch and a cooker to process crayfish and prawns aboard the vessel were installed. "Tagula" can now handle efficiently several thousand pounds of crayfish or prawns per day. The vessel is shown in Plate 24.

Although data from other vessels and shore investigations are included in the following reports on prawns, crayfish, &c., the principal effort was from "Tagula" (Table 39). Table 40 gives data on other vessels employed.

Prawn Investigations.

"Tagula" carried out only two short surveys and because of difficulty with the equipment, the prawn survey work was stopped and other work undertaken. In connection with trawling surveys, the Division is experimenting with five different types of gear, viz.:

(i) A beam trawl 6 feet wide for use from small craft; it may operate efficiently when towed by canoes.

(ii) A three fathom try-trawl especially for prawns and used by large commercial vessels. This net may also have possibilities for use from canoes but it would be too small to take worthwhile quantities of fish or prawns unless shoals were very dense.

(iii) Five fathom trawl—an Otter trawl for experimental fishing with small craft; this has been used with limited success from the "Diana".

(iv) An eight fathom trawl. This net is too big for the 30-foot class of vessel and is a commercial trawl. It is used by some Australian fishermen and experiments are planned in connection with chartered vessels.

(v) Twelve to sixteen fathom nets are used on "Tagula" and are suitable for commercial ships with ample power.

Previous investigations show that there are at least eight species of Penaeid Prawn in Papuan waters, three of which are closely related to the Australian Banana and Tiger Prawn species, which are among the most important commercial prawns in Australia.

PLATE 24—*The Fisheries' Research Vessel "Tagula".*
[Photograph Australian News and Information Bureau]

PLATE 25—*Netting Tilapia in a lowland pond.*
[Photograph Australian News and Information Bureau]

TABLE 39.—SUMMARY OF INVESTIGATIONS BY F.R.V. *TAGULA*—1959–60.

Fishing Voyage No.	Duration.	Area.	Type of Investigations.	Results.	Remarks.
31	24.8.59 to 7.9.59	Moresby–Marshall Lagoon–Loupom–Samarai–Brummer Island–Samarai–Moresby	1. Trolling 2. Trawling with try net 3. Transport of Loupom fish to Moresby market 4. Transport of Fisheries Officer and equipment for independent survey to Marshall Lagoon	1. 2,726 lb. 2. No prawns but some small fish taken 3. 515 lb. taken	Weather generally poor. Approximately 1,000 lb. trollfish lost due to poor quality swivels. Best troll catch taken from Brummer Island to Wari Island
32	21.9.59 to 17.10.59	Moresby–Otomata–Loupom–Samarai–Jamard–Rossel Island–Samarai–Hula–Moresby	1. Trolling 2. Trawling with try net 3. Beach hauling with bait net 4. Transport of Loupom fish to Moresby market	1. 3,246 lb. 2. 4½ lb. prawns and 51 lb. small fish 3. 640 lb. garfish and 900 lb. sardines 4. 800 lb.	Unsuitable trolling conditions and owing to breakdown of echo sounder troll catches were poor. Bulk of catch with 3-fathom try trawl were banana prawns—these were taken in shallow water off Otomata. Sardine catches taken inshore at Hula: estimated that tons could be taken at this time of the year
33	11.12.59 to 14.12.59	Moresby–Bavo Island–Idiha Island–Moresby	1. Crayfish survey 2. Trolling	1. Few crayfish taken by *Tagula* crew 2. 75 lb.	Estimated that over 1,000 crayfish per day taken by native fishermen since 1.12.59. Most important species *Panulirus ornatus* var. *decoratus*. Trolling very poor
34	6.1.60 to 15.1.60	Moresby–Yule Island–Moresby ..	1. Crayfish survey 2. Trawling with try net	1. 1,049 crayfish purchased from native fishermen, cooked and returned to Moresby for sale 2. Only one tiger prawn taken at mouth of St. Josephs River. Few scallops	F.R.V. *Tagula* unable to handle the number of crayfish available for sale
35	3.2.60 to 8.2.60	Moresby–Hula–Loupom–Moresby ..	1. Trolling 2. Checking Loupom freezer and fishing gear 3. Checking crayfish run and oyster abundance	1. 14 lb. 2. Good 3. No crayfish run and oysters examined small	Only two yellowfin tuna taken. Weather very poor for trolling—water discoloured by heavy rain. The crayfish run does not extend to the south-east of Moresby

TABLE 39—*continued.*

Fishing Voyage No.	Duration.	Area.	Type of Investigations.	Results.	Remarks.
36	17.2.60 to 19.2.60	Moresby–Yule Island–Moresby ..	Crayfish survey	2,078 crayfish purchased from native fishermen in 45 hours at 2s. 0d. each	F.R.V. *Tagula* unable to handle all crayfish available for sale. Majority cooked ashore and returned to Moresby
37	2.3.60 to 22.3.60	Moresby–Abau–Loupom–Samarai–Gaba Gabuna – Samarai – Suau – Loupom – Moresby	1. Oyster cultivation 2. Fishing with ring and mesh nets .. 3. Trolling.	1. Oyster racks, clam shells and trays put down for spat collection and subsequent cultivation 2. Ring net unsuccessful as mullet jumped both net and skirt 3. Poor—unable to stay over sunken barrier	Quantities of fish in Gaba Gabuna Bay small and doubtful whether they would stand concentrated fishing with improved gear
38	4.4.60 to 12.4.60	Moresby–Yule Island–Jokea–Cape Possession–Moresby	Crayfish survey: 1. Experimental traps (hessian covered cray pots and 2-ft. diameter rings with net under) 2. Bottom gill nets	1. Seven crayfish 2. 35 lb. reef fish	At time of survey inshore crayfish season had finished. These experiments showed that with covered pots and with dilly traps, crayfish can be taken and are definite meat eaters

TABLE 40.—FISHERIES SURVEYS BY SHIPS OTHER THAN *TAGULA* (INCLUDING CHARTERS AND ADMINISTRATION VESSELS) FROM JULY, 1959, TO JUNE, 1960.

Vessel.	Area.	Duration.	Type of Fishing.	Total Catch. lb.	Dissected Catches. lb.	Remarks.
M.V. *Cutty Sark* (Charter)	Galley Reach ..	6.7.59 to 10.7.59	Gill netting.. ..	2,992	119 barramundi 173 other spp. 2,700 shark	
M.V. *Diama* (Fisheries vessel)	Fishermens Island ..	2.9.59 to 4.9.59	General survey ..	Nil	Nil	Investigations close inshore and Lebulebu reef
M.V. *Koro* (Government trawler)	Hankow Reef ..	26.9.59 to 27.9.59	Troll and handline ..	491	399 troll C/TLH = 34.6 92 handline C/HLH = 15	Due to distance from Madang (7½ hours) lack of safe anchorages, small area of reef, doubtful whether commercial fishing would be profitable
M.V. *Koro* (Government trawler)	Long Island, Hankow Reef	24.10.59 to 26.10.59	Troll and handline ..	309	182 troll C/TLH = 14.5 127 handline C/HLH = 46	Catches again poor
M.V. *Kae* (Charter) ..	Hula	30.10.59 to 6.11.59	Bait fishing ..	..	..	..
M.V. *Diama* (Fisheries vessel)	Kaparoka	14.11.59 to 27.11.59	Bait fishing ..	500	Spats and anchovy	Salted and dried—product fair
M.V. *Diari* (Charter) ..	Galley Reach ..	24.11.59 to 4.12.59	Gill netting ..	2,772	460 barramundi 62 other spp. 2,250 shark	..
M.V. *Diari* (Charter) ..	Marshall Lagoon ..	10.12.59 to 21.12.59	Gill netting.. ..	1,240	427 barramundi 127 other spp. 696 shark	..
M.V. *Diari* (Charter) ..	Galley Reach ..	11.1.60 to 23.1.60	Gill netting.. ..	2,703	607 barramundi 399 other spp. 1,697 shark	Barramundi spawning during this month
M.V. *Diama* (Fisheries vessel)	Idiha Island	3.2.60 to 5.2.60	Crayfishing survey ..	12 cray	5 red crays 7 green crays	Crays were deep and only stragglers taken inshore

TABLE 40—*continued.*

Vessel.	Area.	Duration.	Type of Fishing.	Total Catch. lb.	Dissected Catches. lb.	Remarks
M.V. *Eros* (Government trawler)	Milne Bay	11.2.60 to 19.2.60	..	..	..	Dr. Rapson and Mr. Van Pel inspecting native fisheries between Moresby and Milne Bay
M.V. *Tangallooma* (Charter)	Long Island, Crown Island, Hankow Reef	29.3.60 to 2.4.60	Troll and handlining	1,017	591 troll C/TLH — 16.4 426 handline C/HLH = 106.5	These three areas all have poor anchorages and are difficult to work in north-west. Best catches at Hankow Reef
M.V. *Koro* (Government trawler)	Karkar, Bogia, Hatzfeldt	12.4.60 to 15.4.60	Troll and handline ..	Nil	..	Inspection of area only. Fish very scarce
M.V. *Diari* (Charter) ..	Marshall Lagoon ..	22.4.60 to 11.5.60	Gill netting.. ..	2,036	577 barramundi 151 other spp. 1,308 shark	..
M.V. *Langu* (Charter) ..	North-west coast of New Britain	25.5.60 to 5.6.60	Whitebait survey. Gill netting	200	100 whitebait 100 gilled fish	Whitebait failed to run in any quantity
M.V. *Koro* (Government trawler)	Karkar, Manam, Bogia	25.4.60 to 15.5.60	Troll and handline. Seine netting	50	..	Very little reef around these islands. Beaches steep covered with pumice. Handlining very poor due to nature of bottom
M.V. *Diari* (Charter) ..	Loupom and Samarai ..	31.5.60 to 19.6.60	Lampara netting ..	78	..	Survey for live bait in inshore waters between Moresby and Loupom. Strong south-east winds and rough seas made shooting difficult and catches very small

NOTE.—C/TLH = Catch per troll line hour.
C/HLH = Catch per hand line hour.

Apart from the operations directed particularly at fishing, the following information collected in other work has considerable bearing on subsequent prawn work:

(i) Crustaceans washed ashore in large numbers in Orangerie Bay on the south coast of Papua during the early part of the south-east season were probably young prawns.

(ii) An upstream migration of small prawn-like organisms has been reported at Orapiu (south of Iokea) in the Eastern gulf.

(iii) From Daru small prawns were taken in inshore beach netting with small mesh nets.

(iv) Small prawns were taken in the sea near Madang and in rivers. In view of the equipment used it is probable that considerable quantities are to be found in the near vicinity.

(v) In biological work on barramundi, the stomach contents regularly showed the presence of prawns and this finding is quite widespread from Marshall Lagoon to Galley Reach and Daru. Spanish mackerel to the east of Samarai in the region of Kosmann Island, Imbert Island and Steurs Island usually had small prawns in the stomach. Depth of bottom is eighteen fathoms.

Crayfish.

In the season 1959–60, crayfish (*Panulirus ornatus*) were found close to Port Moresby in considerable numbers. This is the first big run of crayfish near Port Moresby since 1950. In December, 1959, it is estimated that 17,000 crayfish were brought to Koki market and a very large proportion were found in the shallow water between Bavo Island and Idiha Island. After the first big run, smaller numbers were caught but in the three months December, 1959 to the end of March, 1960, it is estimated that more than 30,000 crayfish were sold at Koki market at a price varying from 2s. to 5s. each.

No detailed biological work has been carried out on this species but the following observations relating to the big run which occurred in this year are made:

(i) Crayfish are usually found in shallow water after a fresh north-west blow. It is possible that this type of offshore wind may bring cold water from the bottom and in this way make the normal habitat of crayfish too cold. After a period without wind, the crayfish often retire to a minimum of 50 feet and are then taken only with difficulty by skin-divers.

(ii) The crayfish which come inshore are either in spawning condition or spent. In the first part of the season, a big proportion of the females carried eggs and as the season progressed, a proportion was found to have lost their eggs. The crayfish were all in an extremely weak condition and there was little meat in their legs. This factor probably relates to the need for the crayfish to seek sheltered warm water when the north-west wind blows strongly.

(iii) Some of the crayfish examined were feeding actively and contained in the stomach crushed shell-fish and other small crustacean remains. The crayfish in coming from deep water are found in a wide variety of habitats from open weed flats to coral reefs where they have ample protection. They are caught by Native fishermen using spears and nets; when fishing reef areas, the crays are chased from crevices by artificial octopus made from teased ropes.

In January and February 1960, 1,050 and 2,050 crayfish respectively were purchased from Native fishermen working the Yule Island reefs. The crayfish were cooked ashore and returned to Port Moresby for sale. M.V. "Leander", operated by Coral Sea Products, also caught several trial shipments and these were forwarded to the Sydney fish market where they were sold at approximately 4s. per lb. The purchase price was 2s. and the average weight in January was 2 lb. 12 oz. and in February 2 lb. 4 oz.

In November, rings with nets attached were set off Yule Island, baited with fish heads. No crayfish were caught. There were, however, few in the area at this time. Later in the season off Iokea, in April when many crayfish were about, hessian covered traps baited with fish were successfully used to catch a few crayfish. It appears, however, that this species is reluctant to enter pots. The amount of food required to feed such a large run of crayfish must be very considerable and it is still not known if the crayfish, in coming ashore, come in to escape the unfavorable environment or to seek food. An observation from Manus Island

is relevant. Crayfish are said to come inshore where they shelter in the honeycomb coral and care for their young for several weeks before the young hatch. The adults then move away and leave the young crayfish under the coral.

Trolling.

In previous years a considerable part of " Tagula " operations was directed to locating good trolling areas and it was reported that trolling could be economically sound in the Territory, provided electronic echo-sounding were employed. Work is arduous and the returns not always commensurate with the effort. However, one vessel trading on the north coast of Papua and east of Samarai now regularly trolls for mackerel and pays all fuel expenses from the sale of the fish caught.

In connection with other activities, " Tagula " made two trolling fishing voyages and in a total of 33 days, 251 hours were spent trolling good reefs for a total of 5,100 lb. of fish. Over the sunken barrier, results obtained this year were not as good as previously. The sunken barrier is the most productive Spanish mackerel area in Papua and New Guinea.

Some investigations were made in trolling below the surface. The equipment used, paravanes of different types, did not operate with any great success, but when large fish are present, paravanes catch more in fair weather than surface trolling and lines.

In clear water, shoals of mackerel containing perhaps twenty or thirty fish could sometimes be seen near the bottom at about 10 fathoms depth. As the vessel passed over these, one or sometimes two fish would be caught, but the mackerel never came to the surface and followed the lures as they have been found to do in Australian waters and in Papua in the Bramble Cay region.

Madang Fishery Development.

The Division has operated a series of assistance projects directly aiding native fishing groups in this area in which fisheries are not well developed in the native economy. With continued European supervision, fishing is regularly carried out in fair weather, but when the fish runs decline and the weather is not good, the fishing effort is considerably reduced. However, in the villages which receive assistance, Yabob, Surumarang, and Bongu, considerable revenue has been received from the sale of fish to nearby markets or in Madang.

An extension of the work in the immediate vicinity of Madang to Murik Lakes and Sisano Lakes shows that in both places the situation is similar to that in Madang. There are at times substantial quantities of fish, prawns and in the latter places shell-fish, for which there is a considerable demand. There is a lack of skilled village fishermen with the knowledge of how to transport the fishery products mentioned and it is only occasionally that fish from the Murik Lakes reach the European market. Part of the reason for lack of development, however, is the irregular and high cost of freight and this, combined with the perishable nature of the cargo, makes fishing for this market a hazardous undertaking.

Although the projects in this area can be classed as only partly successful, a combined search for better and more profitable fishing methods and grounds is warranted by the evidence obtained up to the present time. Off-shore fishing on the Hankow Reef has produced promising results and, with the reefs around Karkar and Bagabag Island, offers a potential fishery which would be sufficient to supply a very considerable population. Untouched as yet also is the Tuna fishing, which on this part of the coast is relatively close inshore. It is fished regularly by foreign vessels. Inshore also there are extensive areas of shallow water which are suitable for trawling but which have not yet been fully tested.

Miscellaneous Fisheries Investigations.

Netting Surveys.

Table 41 gives results of some of the more important netting surveys undertaken.

A survey of the north coast of New Guinea extending over the period 1958–59 into 1959–60 is not included as it was of a different nature. This Papuan series of experiments is directed mainly to barramundi research. The quantity taken is not great, partly because of the limited transport facilities.

TABLE 41.—SOME NET FISHING SURVEYS OF THE TERRITORY OF PAPUA AND NEW GUINEA—JULY, 1959, TO JUNE 1960. WEIGHT IN POUNDS.

Location of Patrols.	Duration.	Barra-mundi.	Mullet.	Trevally.	Mangrove Jack.	Leatherskin.	Catfish.	Sicklefish.	Sharks.	Miscel-laneous.	Total.
Laloki River (7 days)	28.7.59 to 3.8.59	203	20	..	..	..	84	..	..	136	443
Marshall Lagoon No. 2 (16 days)	24.8.59 to 8.9.59	336	64	2	4	62	..	3	604	12	1,087
Abau (18 days)	7.10.59 to 24.10.59	372	285	27	16	70	225	4	3,241	842	5,082
Manumanu (11 days)	24.11.59 to 4.12.59	460	..	..	2	19	10	..	2,250	31	2,772
Marshall Lagoon No. 3 (11 days)	11.12.59 to 21.12.59	427	4	8	3	18	..	6	696	47	1,209
Galley Reach (10 days)	25.11.59 to 4.12.59	460	..	..	2	19	10	..	2,250	31	2,772
Galley Reach (14 days)	11.1.60 to 23.1.60	607	..	..	..	76	..	1	1,697	292	2,673
Marshall Lagoon No 4 (19 days)	23.4.60 to 11.5.60	577	..	14	14	73	..	14	1,308	25	2,025
Daru (21 days)	6.6.60 to 27.6.60	719	..	..	..	..	..	..	..	20	739
Total	..	4,161	373	51	41	337	329	28	12,046	1,436	18,802

Mullet.

During the year investigations were continued into the seasonal run of mullet up the Gulf Rivers. These upstream migrations are reported every year from a number of rivers and at times the quantity of fish is very great. No success has been obtained in any investigation up to the present time and it appears that the runs, although of considerable size, are often of such short duration that unless the fisherman is actually stationed on the river at the time the shoals move upstream, the run is over before sufficient equipment can be brought to the site. Areas investigated have included the Kerema and Vailala Rivers.

Milk Fish.

This important Indo-Malayan species is frequently taken in New Guinea waters. There is also evidence that fish ponds have been developed from natural inshore lagoons (Port Moresby and Madang) in which the species was cultivated. In Port Moresby, seasonally, milkfish of 20 lb. weight and over are taken, while in the Murik Lakes mainly small fish are caught. Investigations are continuing to find out more about the early larval stages with the aim of developing this fishery and, if possible, introducing pond culture.

Whitebait.

The principal New Guinea whitebait is a goby species and the runs which occur for many months of the year are often of enormous size. Samples collected in June of this year and shipped to Sydney were reported to be good and when canned the taste was excellent. However, the appearance was reported to be not as attractive as Tasmanian or New Zealand whitebait. This New Guinea goby has commercial possibilities and, although the runs are irregular, the keeping qualities appear to be such that the fish can be kept in shallow water for a considerable period without suffering any damage, and this may be a method of storing the catch without ice, pending transport.

Barramundi.

A considerable amount of information has been collected on the migrations, feeding and breeding of barramundi. The data are generally comparable with those given in a corresponding study with Australian barramundi.

Principal findings are:

(i) Sea run fish are taken principally in October to March, but at other seasons small runs occur, possibly related to freshes in the rivers and possibly also to the penaeid prawn migration.

(ii) Barramundi feed a lot on prawns which may constitute 50 per cent. of their food in certain places.

(iii) Spawning probably takes place near the end of the north-west season. The eggs are small and have oil globules but sink in the heavy inshore seawater.

(iv) The river fish which can be caught in the dry season are not of the same high quality as food as are sea run fish.

(v) Investigations show that sharks are the greatest predator of barramundi.

Sharks.

The Division sent two shark expeditions to areas where shark attacks were reported—one near Madang and the other near Port Moresby. On both occasions the gear used caught a large shark, believed to be the rogue shark which had made the attacks. The gear—special shark hook (meat bait) with chain and ample strong line with anchor and float—was set about ten days after the attack and this method is recommended for future work. The Madang shark had made several attacks before the gear was set and this follows the theory that sharks develop habits, and after any attack on a human, special efforts should be made to catch them.

Crocodiles.

It was thought that the nets of heavy nylon twine used for barramundi would effectively catch crocodiles. Experience has shown, however, that although a few are caught, crocodiles are able to take fish from a net without becoming entangled in it, and shooting, trapping and possibly fishing with specially prepared hooks should be carried out to rid densely populated areas of rogue crocodiles. During the fishing surveys in Marshall Lagoon in the current year, several crocodile attacks took place on native women in canoes and ashore.

PLATE 26—*A fish smokehouse of Papuan design.*
[Photograph Australian News and Information Bureau]

Dugong.

This species is not now very plentiful and although a few are marketed each year and the meat is highly esteemed by native people, consideration should be given to protecting dugong.

With the increasing use of small motor boats, the hunting of dugong will be intensified with a consequent further decline in numbers. The species appears to be particularly vulnerable when nursing.

Turtles.

No detailed investigations into turtle fisheries are being made. There is widespread interest in turtles and in a number of places they are domesticated, being kept in pens in the sea and regularly fed animal and vegetable food.

There is ample scope for research into rearing turtles, as although the female produces large numbers of eggs which hatch in relatively secure conditions, the mortality for the first few weeks after hatching is considerable. Sea-gulls and fish both feed on the newly hatched turtles. A large trevally was found with three turtles in its stomach.

Experimental turtle rearing pens, to take turtles through the first few months after hatching, have been recommended. The actual collecting of the young is the principal problem and the collecting of eggs and hatching under artificial conditions could not easily be accomplished; it is doubtful if eggs could be collected from the positions in which they are laid and transported to suitable sand bins with the correct pressure and humidity to permit satisfactory hatching. Six eggs kept in moist sand were dried out in five days.

Smoked, Dried and Salted Fish.

One of the principal reasons for the lack of acceptance of smoked or dried fish is that the local market normally uses fresh fish or soft smoked cooked fish without salt. This product is popular and although the keeping time is short, it is a quick method of keeping a catch of fish which cannot be sold for about 36 hours. This type of fish is little different from cold freshly-grilled fish. A Native fish smoking house is shown in Plate 26.

The work which commenced at Murik Lakes in 1958–59 is only partially successful and the quantity of fish produced for the Wewak market has not been great. Irregular transport and high transport costs have militated against the success of this project; it is suspected also that there is not very much enthusiasm for regular organized fishing outside the normal custom, and trade in the traditional methods is still favoured. This relates to exchange of fish for vegetables and netting materials.

It is not possible to say if the scheme, as developed by the Division of Fisheries, is in the best interests of the native economy, as, in the Loupom area where the native population is very much more advanced, intensive fishing for market in the European manner may have actually reduced the amount of fish normally consumed in the village.

The native fishing economy is not intensively developed, and with few exceptions, fishing for village use is carried on within several miles of the village. Only when an industry can be developed, producing regularly many times the daily needs of a village, will it become economic to hold surplus products for storage or shipment to other markets.

The present method of using a surplus is to trade inland to nearby villages and what cannot be used immediately is fed to domestic animals. This method of disposal appears to be so ingrained in native custom that literally a fishing revolution would be needed to change the custom.

Oyster Cultivation.

A second attempt to cultivate edible oysters was made near Gabagabuna in Milne Bay. Silt deposition on the shells and attacks by marine borer on the frames of the stand were principal causes of loss, which amounted to approximately 40 per cent. in four months. Growth was best near the rich green water of Gabagabuna Bay which is sufficiently out of the area where fine sand and silt normally move. Green water and fine silt are indications of good growing conditions for some species of oyster. In Galley Reach where the first experiment was made, predation by fish was a major cause of loss. In Milne Bay this was avoided by using shallow wire trays of $\frac{1}{2}$-in. mesh covered on top.

The method offers promise and with constant supervision, would yield regular supplies of oysters. Experiments are continuing with the aim also of cultivating other species of shellfish which have a relatively high value. The cultivation of several species of clams, widely practised in the Manus area, shows that success lies partly in the selection of species and partly in the habitat chosen, which is not necessarily of the type or locality in which the shellfish are found e.g. some clams from the surf-beaten reef are planted in inshore sheltered waters where growth may be more rapid than in the normal habitat.

Fish Meal.

Trawl catches exceeding 1,000 lb. of small fish per fifteen minute haul have been made The work of storing such fish is impracticable and in surveys, most catches of this size are shovelled back into the sea. Several experiments in refrigeration show that these small fish dry out too quickly and are unattractive after several days freezing. They could be kept with ice but the cost would not warrant this treatment as the market value is only about 1s. per pound. A small sample of 350 lb. was cooked on board "Tagula" and dried in a copra drier ashore and then in the sun. The resulting product put through a hammer mill still contained a rather obvious amount of scale and bone and on analysis contained 6 per cent. of oil and approximately 60 per cent. protein. The quantities of small fish which are available in some places could warrant the establishment of small meal plants to handle five tons of meal per day. Economic production is considered possible.

Synthetic Net Materials.

Experience has shown that natural fibres such as cotton, tree bark, hemp, &c., do not last very long, even after receiving careful treatment and modern preservation. Experiments have now been directed towards determining the most economic synthetic materials.

Contrary to previous belief, trawl nets of nylon can be used without serious abrasion. In mesh netting, the principal difficulty with some types is the difficulty of obtaining nets in which the knots do not slip too much. Mesh netting probably offers the greatest scope for development in native fisheries and nets are used from about $1\frac{5}{8}$-in. of very fine twine for catching *Selar* in the Manus group to 8-in. mesh, 360 lb. breaking strain, for barramundi schools and crocodiles in the Daru area. The principal aim in the experiments with the big mesh nets is to determine the minimum strength of twine which will effectively catch the largest fish. The Queensland fish trap is being tested near Daru where there is a considerable rise and fall of tide.

FRESH WATER FISHERIES.

During the year, introductions of food fish have included carp and further stocks of *Osphronemus gouramy*. Both species have potential use in native economy in the Highlands. The Singapore carp introduced in 1958–59 have already reached a size of 2 lb., which is the best recorded growth rate up to date for a newly introduced fish. Gouramy introduced previously have reached approximately 2 lb. in weight, but growth is relatively slow.

The *Tilapia* introduced in 1954 is still not a highly popular fish in the Highland Regions where growth is slow and few reach a length exceeding 5 inches. The Snake-skin *Trichogaster pectoralis* have grown to about 6 oz. both in the Lowlands and in the Highland ponds but no reproduction has yet taken place. Plate 25 shows netting of *Tilapia* in a lowland pond.

Although carp offer the greatest potential for pond fish culture in the Highlands, further experiments will be continued before they are distributed as, although the growth rate is rapid, the bad features of carp, namely, muddying of the water by stirring up the bottom and the poor quality of flesh according to general European taste, are factors which need further investigation. The fish have reproduced but not on a sufficient scale to state that they have been successfully bred in ponds.

Dobel Experimental Station.

The principal work on Highland fish culture is carried out at Dobel near Mount Hagen where a series of ponds is stocked and a one-acre pond is under construction. In the area, the principal food is the sweet potato (*Ipomaea*) and fair results have been achieved by feeding this without any additions. However, at the present time the stocking rate is not high and all species cultivated received considerable quantities of natural food in addition to the sweet potato. Small quantities of leaf material of papaw, sweet potato and grass do not appear to have been eaten but other decomposed products may be consumed on the bottom.

Bomana Quarantine Pond.

Small numbers of species being investigated in the Highlands are held at Bomana near Port Moresby in a series of three concrete ponds, and in natural conditions in a one-acre irrigation pond. Growth, generally, for purely tropical species under conditions at Bomana is superior to that in the Highlands, but the absence of a full-time attendant does not permit the detailed attention to feeding which is given at the Dobel pond.

Lakes Aunde and Peunde.

During the year a short survey of these two lakes at approximately 11,500 feet altitude on Mt. Wilhelm was made. The two lakes, with a total area estimated at approximately one half square mile, are, in their centres, about 28 fathoms deep, with a relatively small area of shallow shelving margin. There is not very much phytoplankton and only small areas of filamentous algae near the margins and no weed. The lakes appear, in fact, to be relatively free of animal and vegetable life but near the bottom considerable numbers of Copepods were taken.

The temperature of these lakes, about 53° F. at the surface and 49°–50° F. at the bottom, offers possibilities for temperate fish culture which could be used to stock a considerable part of the upper Chimbu Valley. Although the stream leaving the lakes is small, it could support small stocks of fish and in the lower reaches the small stream and its tributaries flow into the Chimbu River which, although precipitous in many parts of its upper reaches, could well be stocked with a suitable species to provide some fish in the area, where virtually none exists today.

Enquiries on Pond Culture.

Although numerous enquiries are received concerning the method of construction of fish ponds, most of the interested people are not prepared to spend the time or offer the money for construction of a dam, outlet gates and deepening of the borders to ensure a highly productive pond.

There is considerable evidence that properly constructed ponds only two feet deep can, in sheltered parts of the Highlands, supply worthwhile quantities of fish. Continual fertilizing or artificial feeding is necessary and although the species produced up to the present time are not large, in some places a substantial quantity of fresh fish is provided for the local labour employed.

COMMERCIAL DEVELOPMENT.

A few business men continue to have an interest in commercial development of Fisheries. The principal activities have included:

(i) Inshore fishing at Keravat (Rabaul) for sea fish, using native fishermen.

(ii) Fishing the whitebait run at the mouth of the Warangoi River, New Britain.

(iii) Crayfishing at Yule Island (Eastern Gulf of Papua).

(iv) Handlining out of Lae, Madang and Rabaul; European-organized native fishing.

(v) Increasing numbers of Papuans have made enquiries concerning the use of ice boxes to fish out of Port Moresby. Some few loans of ice boxes have been made.

These activities are somewhat irregular and often cease for considerable periods. The Division of Fisheries was directly associated with both whitebait and crayfish catching investigations and assisted in the preparation of samples for export. Whitebait were reported to be good, and on canning produced a well-flavoured but slightly darkened product.

Crayfish, because of some shipping delays, did not arrive at market in good condition and there was some criticism of the processing. Painted crayfish, however, are reported to be naturally rather tough and the flesh rather watery. Although the shell of the cooked crayfish is rather dull in appearance, the meat is well flavoured. Recent development in Thursday Island promises better reception of the Painted crayfish on the Australian Market.

PORT MORESBY BIOLOGICAL STATION.

A fisheries' biological station is in process of development at Kanudi near Port Moresby. The erection of the gear technology building gave good facilities for storage of fishing gear and repair of the larger nets, motor boats and fishing dinghys. However, until the Station is a complete unit, properly co-ordinated technological and biological research will not be possible. When completed, the Station will have accommodation for Native staff, including fieldworkers and laboratory workers, a hydrological and biological laboratory, and gear and food technology research sections. If conditions are suitable, the inshore area will be prepared for handling and taking ashore small craft, with the development later of a jetty for loading and unloading directly to the Biological Station and stores.

Both Native and European technical staff are becoming well qualified in elementary biological principles and with the establishment of a biological and hydrological laboratory, the standard of training in both biology and hydrology could be extended. This extension into

theoretical science would serve as a sound background to the development policy now in hand which is, broadly in terms of effort, 50 per cent. to the development of a modern European type of fishing industry and 50 per cent. to the assistance of native fishing. The 50 per cent. of effort directed to modern development is again divided into 35 per cent. practical fishing and 15 per cent. theoretical considerations or scientific research.

LIAISON WITH DUTCH NEW GUINEA.

During the year, the Chief of Division of Fisheries visited, with the South Pacific Commission Fishery Expert, the principal fishery organization of Netherlands New Guinea in Hollandia and saw some of the development work being undertaken by the Fishery Officer in Charge. An exchange of views took place on fishing gears employed, and the best type of development which should be followed was discussed at length. In addition, fresh water fisheries established at Lake Sentani were visited and a gift of Cantonese carp recently introduced to Hollandia was received and successfully taken to Mount Hagen.

HEADQUARTERS CLERICAL AND GENERAL DIVISION.

Mr. R. E. P. Dwyer, Director of the Department from 1952, died in Sydney on the 2nd October, 1959. He was 57 years of age. Mr. Dwyer joined the Department on the 11th August, 1934, as Economic Botanist. After the war, he was promoted to the position of Chief, Division of Agricultural Extension and then to Director.

Mr. F. C. Henderson, who joined the Department in 1936, was appointed Director on 23rd October, 1959. He attended the F.A.O. Coconut Group Conference at Rome during the year.

ORGANIZATION AS AT 30TH JUNE, 1960.

A reclassification of the Department was gazetted on the 2nd June, 1960. Headquarters organization is now as follows:

- DIRECTOR
  - Biometrician
  - Administrative Officer
    - Cadets
    - Statutory Registration
    - Typing
    - Records
    - Library
    - Supply
    - Personnel
    - Relief
  - Agricultural Economist

Staff as at the 30th June, 1960 comprised 46 officers as follows:

Classification.	Permanent.	Temporary.	Exempt.	Total as at 30th June, 1960.	Establishment.
Biometrician	..	..	..	..	1
Agricultural Economist	..	..	..	..	1
Cadets	22	..	..	22	27
Librarian	..	1	..	1	1
Clerks	8	3	..	11	14
Clerical Assistants	..	..	..	..	2
Clerical Assistants (F)	..	4	..	4	5
Stenographer/Typists	3	..	..	3	5
Auxiliary Division	..	5	..	5	6
	33	13	..	46	62
Administration Servants	..	..	..	12	12
Total	33	13	..	58	74

ACCOMMODATION.

The division is located in the Departmental Headquarters at Konedobu, Port Moresby. Improvements in accommodation are anticipated when part of the departmental accommodation at present occupied by another Department is vacated at the end of 1960.

CADETS.

One Agricultural and two Veterinary Cadets completed their cadetships during 1959–60 and commenced duty in the Territory.

BIOMETRICIAN.

This position has remained vacant throughout the year.

AGRICULTURAL ECONOMIST.

The Agricultural Economist assisted officers from the Department of Territories and Bureau of Agricultural Economics with investigations into the Territory cattle industry and coffee industry. He resigned on the 16th January 1960 and the position is still vacant.

LIBRARY.

The Department maintains a central library which receives over 300 periodicals and numerous pamphlets in addition to books. A continuous circulation of periodicals and books is maintained with over 50 Field Stations and Centres. Branch Libraries are maintained in each District Agricultural Office and also at Experiment Stations and Extension Stations and Centres, the size depending on the number of Officers and the type of work they are doing. All Branch Libraries are under the control of the Central Library.

SUPPLY.

Supply Section of the Department processed 705 indents and 2,161 local requisitions during the year.

PERSONNEL.

The introduction of the Administration Servants Ordinance increased the volume of staff work considerably with the necessary changes in records and the concentration of these records at Headquarters. Administration servants employed by the Department at 30th June, 1960, totalled 546. Second, third and auxiliary division officers totalled 299. The staff section processed 26 salary variation schedules (containing approximately 3,000 entries), 20 new permanent appointments, 23 temporary engagements, 34 resignations and approximately 1,000 allowances and claims.

ACCOUNTS.

Departmental cash expenditure during 1959–60 was £857,103 plus capital purchases of agricultural machinery, £36,724, livestock £8,419, and livestock freight payment subsidy of £1,675. Vocabulary stores usage was £149,777. Total expenditure from all sources was £1,053,698. Included in this expenditure was:

£11,106 for the operation of the Hallstrom Trust at Nondugl;

£57,011 for the purchase from Natives of cash crops for resale;

£3,911 for the payment of air freight and Malayan export duty on improved rubber seed from overseas.

Receipts totalled £128,619 compared with £83,035 for 1958–59. The increase was mainly caused by the rise in the price of copra and the increased volume of native cash crops purchased for resale. The increase in this latter activity has created new problems for Headquarters and Field Officers, and new accounting procedures were adopted during the year to account for the purchase, processing and sale of produce. All Field Officers visiting Headquarters during the year spent varying periods with the Accounts Clerk to discuss accounting problems.

REGISTRAR.

The Cocoa Industry Ordinance 1958 came into effect on the 22nd October, 1959, and 42 cocoa fermentaries and 42 cocoa exporters were registered prior to the 30th June, 1960. In addition, 1,077 cocoa growers were registered under the *Cacao Ordinance* 1952. The total number of registered cocoa growers at 30th June, 1960, was 4,332.

RELIEF.

This section was staffed by one clerk throughout the year.

STAFF, DEPARTMENT OF AGRICULTURE, STOCK AND FISHERIES AT 30th JUNE, 1960.

HEADQUARTERS DIVISION.

Director	F. C. Henderson, B.Sc. Agr. (Syd.), M.L.C.
Administrative Officer	G. E. Guthrie
Accounts Section:	
Clerk (Accounts)	V. S. Poole
Clerk	D. Smith
Assistant (F), Grade I	Mrs. E. M. Kelly
Personnel Section:	
Clerk (Staff)	P. A. Chandler
Clerk	N. S. Kenna
Clerk	B. A. Snep
Assistant (Clerical)	Tau Vagi
Statutory Registration Section:	
Registrar	C. R. Fyson
Records Section:	
Clerk	Mrs. M. B. Reid
Assistant (F), Grade I	Mrs. B. J. Hymus
Assistant (Clerical)	Morea Hila
Assistant (Clerical)	Raka Ipi
Assistant (Clerical)	Homoka Doriga
Supply Section:	
Clerk (Supply)	G. R. Broadby
Clerk	B. J. Gough
Assistant (F), Grade I	Mrs. N. P. Price
Assistant (Clerical)	Arua Rei
Cadets:	
Cadet Agricultural Officers	R. F. Anders A. G. Basson P. R. B. Blood T. A. Bull G. P. Campbell R. J. Cheetham C. J. Choat L. A. Douglas R. A. Evers R. R. Fraser P. F. Koch-Emery T. W. Langton W. A. Layton C. C. Martin D. R. Petty P. G. E. Searle R. C. McDonald
Cadet Veterinary Officers	J. A. Hamilton P. R. Harvey D. M. Keenan D. J. Purdy N. T. Talbot
Relief Section:	
Typist (F)	Miss S. M. Devine
Typist (F)	Miss G. Q. E. Crawford
Clerk	Mrs. G. I. Ridge
Library:	
Libraries Officer	Mrs. E. A. Anderson, B.A., Dip. Ed. (Qld.)
Assistant (F), Grade I	Mrs. V. R. Morton
Director's Staff:	
Typist (S)	Miss P. E. Evans

DIVISION OF ANIMAL INDUSTRY.

Headquarters:

Veterinary Officer, Grade III.	J. L. Anderson, B.V.Sc. (Qld.) ..	*Veterinary adviser to Director*
Animal Husbandry Officer, Grade II.	J. F. S. Browne, B.Sc. (Agr.)(W.A.)	*Animal nutrition*
Stock Inspector, Grade III.	W. C. Jamieson	*Stock and meat inspection*
Typist	Miss M. A. McGrath	

Veterinary Laboratory:

Pathologist-Bacteriologist, Grade II.	J. R. Egerton, B.V.Sc. (Qld.) ..	*Pathology and bacteriology services and research*
Manager, Grade II. ..	C. T. Coghlan	

Central District:

Veterinary Officer, Grade I.	R. M. Peebles, B.V.Sc. (Qld). ..	*Veterinary Officer, Port Moresby*
Stock Inspector, Grade I.	R. D. E. Rankin, Q.D.A.H. ..	*Stock Inspector, Sogeri*

Papuan Lowlands Livestock Station, Moitaka:

Manager, Grade III.	D. E. Murray, Q.D.A.H. ..	*Manager*
Overseer, Grade II. ..	C. W. Allman	
Overseer, Grade II. ..	G. D. Gooding	
Overseer, Grade II. ..	N. Nielsen	
Field Assistant ..	D. Moodie	

Papuan Highlands Livestock Station, Bisianumu:

Manager, Grade II. ..	D. P. McColm	*Manager*
Assistant Animal Husbandry Officer	M. G. Meadows, Q.D.A.H.	

Morobe District:

Veterinary Officer, Grade I.	T. L. W. Rothwell, B.V.Sc. (Syd.)	*District Veterinary Officer*
Veterinary Officer, Grade I.	H. C. Grant Frost, B.V.Sc. (Syd.)	*Veterinary Officer, Lae*

Animal Industry Centre and Quarantine Station, 3 Mile, Lae:

Manager, Grade I. ..	V. L. Cunliffe	*Manager*

New Guinea Lowlands Livestock Station, Erap:

Manager, Grade II. ..	C. H. Tomkins	*Manager*
Manager, Grade I. ..	C. R. Kempson	
Overseer, Grade II. ..	I. W. Shaw	

Highlands District:

Veterinary Officer Grade III	P. F. Robinson, B.V.Sc. (Syd.) ..	*District Veterinary Officer, Goroka*
Stock Inspector, Grade II	A. Hantsoo	*Stock Inspector, Banz*

Animal Industry Centre, Goroka:

Manager, Grade II ..	R. R. Bell	*Manager*
Overseer, Grade II ..	M. J. Lewis	

Upper Ramu Livestock Station, Arona:

Manager, Grade I ..	R. Wagenknecht ..	..	*Manager*

Western Highlands Livestock Station, Baiyer River:

Manager, Grade II ..	W. N. St. George ..	..	*Manager*
Overseer, Grade II ..	C. F. Clements		
Overseer, Grade II ..	B. J. Colbran		

New Britain District:

Veterinary Officer, Grade II	J. D. Glasgow, B.V.Sc. (Qld.) ..		*District Veterinary Officer, New Britain*
Stock Inspector, Grade I	A. R. Savage.. ..	..	*Stock Inspector, New Britain*

Animal Industry Centre, Kurakakaul:

Manager, Grade I ..	B. I. Sutherland ..	..	*Manager*
Overseer, Grade I ..	A. Blumson		

Madang District:

Stock Inspector, Grade II	F. L. Corbett ..	..	*Stock Inspector, Madang*

DIVISION OF PLANT INDUSTRY.

Headquarters:

Chief of Division ..	A. W. Charles, B.Sc.Agr. (Syd.), M.Sc. (Cantab.)	
Typist	Miss H. A. Broadby	

Agricultural Chemistry:

Principal Chemist ..	D. W. P. Murty, B.Sc.Agr. (Syd.)	*Copra quality studies*
Senior Chemist ..	P. J. Southern, B.Sc. (W.A.) ..	*Plant nutrition and soil fertility*
Chemist, Grade I. ..	Miss C. A. Fowler, B.Sc. (Melb.)	*Soil and plant analysis*
Laboratory Assistant..	Mrs. D. A. Conyard, Dip. Chem.	*Soil analysis*
Laboratory Assistant..	Morea Raka	
Technical Assistant ..	Jeremiah Iewa	

Economic Entomology:

Senior Entomologist ..	J. J. H. Szent-Ivany, Ph.D. (Budapest)	*Systematic entomology and zoogeography*
Entomologist, Grade II.	A. Catley, B.Sc.Agr. (Syd.) ..	*Economic and systematic entomology* (Heteroptera)

Plant Introduction and Quarantine:

Plant Introduction Officer	G. P. Keleny, B.A. (Qld.), D.D.A.	
Technical Assistant ..	Gumia Gitti	

Plant Pathology:

Principal Plant Pathologist	Miss D. E. Shaw, M.Sc.Agr. (Syd.), Ph.D. (Man.)	*Pathology and taxonomic mycology*
Pathologist, Grade I...	M. J. Trinick, B.Sc.Agr. (Syd.) ..	*Microbiology* (Rhizobium)
Technical Assistant ..	Horatius Igua	

Soil Survey:

Principal Soil Survey Officer	G. K. Graham, B.Sc.Agr. (Syd.), D.T.A. (Trin.)	*Soil survey and land settlement investigations*
Soil Survey Officer, Grade II.	T. R. Morgan, B.Sc.Agr. (Syd.) ..	*Soil survey and drainage investigations*
Soil Survey Officer, Grade II.	A. C. Hartley, B.Agr.Sc. (Qld.) ..	*Soil survey*
Soil Survey Officer, Grade II.	B. G. Williams, B.Agr.Sc. (S.A.)..	*Soil survey and land settlement investigations*
Soil Survey Officer, Grade I.	F. P. Aland, B.Agr.Sc. (Qld.) ..	*Soil survey and land settlement investigations*
Technical Assistant ..	Titus Tatauro	
Technical Assistant ..	Forova Kulu	
Technical Assistant ..	Soldier Piki	
Technical Assistant ..	Noka Kopi	
Technical Assistant ..	Seaka Kabua	

Experiment Stations:

Lowlands Agricultural Experiment Station, Keravat:

Principal Agronomist	L. A. Bridgland, B.Sc.Agr. (Syd.), D.T.A. (Trin.)	*Cacao improvement and processing*
Principal Entomologist	G. S. Dun, B.Sc.Agr. (Syd.) ..	*Economic entomology (biological control)*
Senior Agronomist ..	R. S. Carne, B.Agr.Sc. (Melb.), D.T.A. (Trin.)	*Coffee improvement*
Senior Chemist ..	S. C. Baseden, B.Sc. (W.A.) ..	*Plant nutrition*
Agronomist, Grade III.	A. E. Charles, B.Sc.Agr. (Syd.) ..	*Coconut improvement and agronomy*
Agronomist, Grade III.	P. N. Byrne, B.Agr.Sc. (S.A.) ..	*Cacao breeding and agronomy*
Plant Pathologist, Grade II.	R. J. Van Velsen, M.Agr.Sc. (S.A.)	*Virus pathology*
Entomologist, Grade I.	L. Smee, B.Sc.Agr. (Syd.) ..	*Economic entomology (chemical control)*
Agronomist, Grade I.	J. B. O'Donohue, B.Agr.Sc. (Qld.)	*Cacao processing and manila hemp breeding*
Agronomist, Grade I.	G. I. Jamieson, B.Agr.Sc. (Qld.)..	*Food crop improvement*
Horticulturalist/Experimentalist, Grade II.	I. L. Edward, H.D.A.	*Cacao propagation investigations*
Typist	Miss R. Schneider	
Overseer, Grade II. ..	K. C. Williams	
Field Assistant ..	L. Enkera	
Plant Operator ..	R. Luker	
Mechanic	R. J. McNicoll	

Highlands Agricultural Experiment Station, Aiyura:

Senior Agronomist ..	A. J. Schindler, M.C., B.Agr.Sc. (Qld.)	*Pyrethrum breeding*
Agronomist, Grade III.	K. Newton, B.Sc.(Agr.) (W.A.), D.T.A. (Trin.)	*Coffee agronomy and farming systems investigations*
Entomologist, Grade II.	J. H. Barrett, B.Agr.Sc. (Qld.) ..	*Economic entomology (coffee and vegetable pests)*
Horticulturalist/Experimentalist, Grade I.	K. van Horck, Dip. Hort. (Boskoop)	*Propagation*
Field Supervisor, Grade II.	H. Nitsche	*Livestock*

Epo Agricultural Experiment Station:

Agronomist, Grade II.	R. W. Strickland, B.Sc. Agr. (W.A.)	*Annual crop agronomy*
Agronomist, Grade II.	P. L. Stallwood, B.Sc. Agr. (W.A.)	*Rice breeding and agronomy*
Field Supervisor, Grade I.	C. J. Ryan	
Carpenter	G. English	

Bubia Plant Industry Centre:

Agronomist, Grade I.	C. S. Edwards, B.Sc.Agr.(Syd.) ..	*Agrostology, cacao and annual crops*
Entomologist, Grade II.	J. H. Ardley, B.Sc. (Wellington)..	*Economic entomology (cacao, coconuts and fibres)*
Field Supervisor, Grade II.	W. J. Hughes	*Fibre processing*
Overseer	T. Williams	

Laloki Plant Introduction and Quarantine Station:

Horticulturalist/Experimentalist, Grade II.	R. S. Montgomery, Q.D.H.	
Technical Assistant ..	Kana Aburu	

Bisianumu Rubber Centre:

Horticulturalist/Experimentalist, Grade II.	A. Van Haaren, Dip. Hort. (Boskoop)	*Rubber investigations*

Garaina Experimental Tea Plantation:

Manager	T. G. Henderson	*Commercial tea production*
Field Supervisor ..	J. Vermeer	

Yambi Experimental Plots:

Field Supervisor ..	G. Johnston

DIVISION OF EXTENSION AND MARKETING.

Headquarters:

Chief of Division	W. L. Conroy, B.Sc.Agr. (Syd.)
Principal Agricultural Officer	J. C. Lamrock, B.Sc.Agr. (Syd.), D.T.A. (Trin.)
Agricultural Officer, Grade III.	S. P. Saville, B.Sc.Agr. (Syd.), D.T.A. (Trin.), Dip. Ed. (Syd.)
Agricultural Officer, Grade II.	M. J. B. White, D.D.A.
Agricultural Officer, Grade II.	I. Y. Montgomery, B.Agr.Sc. (Melb.)
Agricultural Officer, Grade II.	W. R. Stent, B.Agr.Sc. (Melb.), D.T.A. (Trin.)
Senior Mechanical Equipment Inspector ..	A. Jefford, M.I.A.E.
Typist	Miss A. Millistver

Western District:

Daru ..	Agricultural Officer, Grade II. ..	F. J. Broekhals, Dip. Ag. (Deventer)

Gulf District:

Kerema ..	Agricultural Officer, Grade III. ..	F. X. Ryan, H.D.A.
Cupola ..	Agricultural Officer, Grade I. ..	D. Birmingham, Q.D.A.
Murua ..	Project Manager	A. B. Wales

Central District:

Port Moresby	Agricultural Officer, Grade III. ..	F. Kleckham, Q.D.A.
Port Moresby	Agricultural Officer, Grade I. ..	R. E. McCormac, H.D.A.
Port Moresby	Produce Inspector	G. Gaskell
Beipa ..	Agricultural Officer, Grade I. ..	L. F. Green, D.D.A.
Kapogere ..	Agricultural Officer, Grade I. ..	J. J. Nitsche, Q.D.A.
Kapogere ..	Manager, Grade II.	W. A. Thistlethwaite
Mageri ..	Agricultural Officer, Grade III. ..	G. L. Edwards, H.D.A.
Mageri ..	Field Assistant	Albert Luckie
Epo ..	Mechanical Equipment Inspector	J. C. Harley

Milne Bay District:

Samarai ..	Principal Agricultural Officer ..	W. Cottrell-Dormer, M.Sc.Agr. (Qld.)
Samarai ..	Agricultural Officer, Grade II. ..	K. I. Tomlin, W.D.A.
Samarai ..	Agricultural Officer, Grade I. ..	E. Mobbs, H.D.A.
Samarai ..	Agricultural Officer, Grade I. ..	J. C. Owen-Turner, Q.D.A.
Samarai ..	Agricultural Officer, Grade I. ..	W. J. B. Heath, R.D.A.
Samarai ..	Produce Inspector	F. Carstensen
Samarai ..	Field Assistant	Edward Nigea
Samarai ..	Field Assistant	Erico Foieke
Samarai ..	Field Assistant	Saki Metu

Northern District:

Popondetta ..	Agricultural Officer, Grade I. ..	M. H. M. Belfield, L.D.A.
Popondetta ..	Agricultural Officer, Grade I. ..	R. Van Schilfgaarde, Dip. Ag. (Deventer)
Popondetta ..	Agricultural Officer, Grade I. ..	R. Tevlin, D.D.A.
Popondetta ..	Manager	J. Bell
Kokoda ..	Agricultural Officer, Grade I. ..	F. K. Mayer, H.D.A.

Morobe District:

Lae ..	Senior Agricultural Officer ..	E. Wilson, Q.D.A.
Lae ..	Agricultural Officer, Grade II. ..	M. J. Mead, R.D.A.
Lae ..	Agricultural Officer, Grade I. ..	A. N. Gillison, Q.D.A.
Lae ..	Mechanical Equipment Inspector	A. G. Donaldson, A.M.I.A.E.
Lae ..	Produce Inspector	A. Phillips
Finschhafen	Agricultural Officer, Grade I. ..	K. G. Newton, Q.D.A.
Finschhafen	Project Manager	T. Otterspoor
Wau ..	Agricultural Officer, Grade I. ..	W. Minchin, M.D.A.
Kaiapit ..	Agricultural Officer, Grade I. ..	D. Macauley, H.D.A.

Madang District:

Madang ..	Agricultural Officer, Grade III. ..	R. Vicary, D.D.A.
Madang ..	Agricultural Officer, Grade III. ..	R. Cottle, Q.D.A.
Madang ..	Manager	N. Blood
Madang ..	Produce Inspector	W. Spencer
Madang ..	Produce Inspector	W. Gossner
Madang ..	Field Assistant	Nayala Tom

Madang District—continued.

Saidor ..	Agricultural Officer, Grade I. ..	B. R. Johnston, R.D.A.
Bogia ..	Agricultural Officer, Grade I. ..	J. Cox, H.D.A.
Kar Kar ..	Agricultural Officer, Grade I. ..	B. J. Beil, Q.D.A.

Sepik District:

Wewak ..	Agricultural Officer, Grade III. ..	D. J. Carey, Q.D.A.
Wewak ..	Agricultural Officer, Grade I. ..	N. G. Tolson, D.D.A.
Bainyik ..	Agricultural Officer, Grade II. ..	D. C. Shepherd, Dip. Ag. (Denmark, W.A.)
Bainyik ..	Agricultural Officer, Grade I. ..	D. E. Montgomery, H.D.A.
Bainyik ..	Project Manager	J. Burgin
Bainyik ..	Mechanical Equipment Inspector	W. Way
Bainyik ..	Field Assistant	Nerga Mark
Bainyik ..	Field Assistant	Mesea Mesea
Bainyik ..	Field Assistant	Gottae Muia
Aitape ..	Agricultural Officer, Grade I. ..	M. J. Griffiths, M.D.A.
Yangoru ..	Agricultural Officer, Grade I. ..	J. A. Wallis, H.D.A.

Southern Highlands:

Mendi ..	Agricultural Officer, Grade I. ..	F. Arndt, Q.D.A.
Mendi ..	Agricultural Officer, Grade I. ..	P. Owers, Q.D.A.

Western Highlands:

Mount Hagen	Agricultural Officer, Grade III. ..	G. Angell, M.D.A.
Korn Farm ..	Agricultural Officer, Grade I. ..	M. Mulder, Dip. Ag. (Deventer).
Korn Farm ..	Field Supervisor	F. Smyth
Korn Farm ..	Overseer	J. Fox
Minj ..	Agricultural Officer	P. Dillon, H.D.A.

Eastern Highlands:

Goroka ..	Agricultural Officer, Grade III. ..	D. J. Kingston, Q.D.A.
Goroka ..	Agricultural Officer, Grade I. ..	G. H. Dick, B.Sc.Agr. (Syd.)
Goroka ..	Project Manager, Grade III. ..	R. B. Duncan, H.D.A.
Henganofi ..	Agricultural Officer, Grade I. ..	D. J. Edwards, B.A. (Cantab.)
Kainantu ..	Agricultural Officer, Grade II. ..	G. M. Hawley, M.D.A.
Okapa ..	Agricultural Officer, Grade I. ..	A. D. Hunt, M.R.A.C. A.I.C.T.A.
Kundiawa ..	Agricultural Officer, Grade III. ..	K. Cole, B.Sc. (Agr.) (W.A.)
Kundiawa ..	Agricultural Officer, Grade I. ..	P. B. Allan, B.Agr.Sc. (Melb.)
Kundiawa ..	Field Assistant	Hetai Dickson
Chuave ..	Agricultural Officer, Grade I. ..	J. C. Hall, D.D.A.
Onamuga ..	Agricultural Officer, Grade I. ..	R. Teale, D.D.A.

Manus District:

Lorengau ..	Agricultural Officer, Grade I. ..	P. U. C. Hermann, Q.D.A.

New Ireland District:

Kavieng ..	Agricultural Officer, Grade I. ..	P. D. Ramm, B.Sc. (Agr.) (W.A.)
Kavieng ..	Agricultural Officer, Grade I. ..	J. H. Sharp, D.D.A.
Kavieng ..	Agricultural Officer, Grade I. ..	N. G. Tolson, D.D.A.
Kavieng ..	Produce Inspector	C. Reason
Kavieng ..	Field Assistant	Kaekae Avaisa

New Britain District:

Rabaul ..	Senior Agricultural Officer ..	J. W. Barrie, B.Sc.Agr. (Syd.), D.T.A. (Trin.), Dip. Ed. (Syd.)
Rabaul ..	Agricultural Officer, Grade I. ..	S. S. Doumany, B.Sc.Agr. (Syd.)
Rabaul ..	Senior Produce Inspector ..	F. A. Rhoades, H.D.A.
Rabaul ..	Produce Inspector	B. George
Rabaul ..	Produce Inspector	R. Collings
Rabaul ..	Produce Inspector	J. Wilkinson
Rabaul ..	Produce Inspector	D. Mullaly
Rabaul ..	Produce Inspector	D. Maclean
Rabaul ..	Produce Inspector	D. Askew
Rabaul ..	Produce Inspector	J. Rudd
Rabaul ..	Field Assistant	C. L. Slinger
Rabaul ..	Field Assistant	Moses Simeon
Taliligap ..	Agricultural Officer, Grade III. ..	R. L. Pulsford, B.A. (Qld.), H.D.A.
Taliligap ..	Agricultural Officer, Grade I. ..	B. A. Boniwell, B.Agr.Sc. (Melb.)
Kandrian ..	Agricultural Officer, Grade I. ..	N. Alcorn, Q.D.A.
Talasea ..	Agricultural Officer, Grade I. ..	J. O'Rorke, D.D.A.
Vudal ..	Manager, Grade III.	W. A. Ovenstone

Bougainville District:

Kieta ..	Agricultural Officer, Grade III. ..	A. Boag, Q.D.A.
Kieta ..	Agricultural Officer, Grade I. ..	G. E. Haling, H.D.A.
Kieta ..	Agricultural Officer, Grade I. ..	G. J. Harvey, H.D.A.
Sohano ..	Agricultural Officer, Grade I. ..	R. E. Curtis, D.D.A.
Sohano ..	Agricultural Officer, Grade I. ..	B. A. McBaron, Q.D.A.

DIVISION OF FISHERIES.

Chief of Division	A. M. Rapson, D.Sc. (N.Z.) ..	*Commercial marine products especially Crustacea and shell: introduction of fresh water fishes*
Marine Biologist, Grade III.	D. J. Dunstan, B.Sc. (Melb.) ..	*Troll and handline fishing: estuarine fisheries, especially barramundi*
Marine Biologist, Grade I. ..	M. Stuart Fox, B.Sc. (Qld.) ..	*Marine ecology, especially oysters*
Marine Biologist, Grade I. ..	R. S. Bucknell, B.Sc. (Qld.) ..	*Freshwater fisheries, especially pond culture*
Fishing Master Engineer ..	J. Hague	*Master, F.R.V.* Tagula
Technical Assistant, Grade II.	J. A. Quinlan	*Inshore and estuarine fisheries*
Technical Assistant, Grade II.	R. F. Price	*F.R.V.* Tagula
Technical Assistant, Grade II.	L. F. Malcolmson	*Inshore and estuarine fisheries*
Technical Assistant, Grade I.	W. Eginton	*Barramundi surveys*

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